

Recent achievements of IMD in the last decade (2014-2023)

4. Recent achievements of IMD in the last decade (2014-2023)

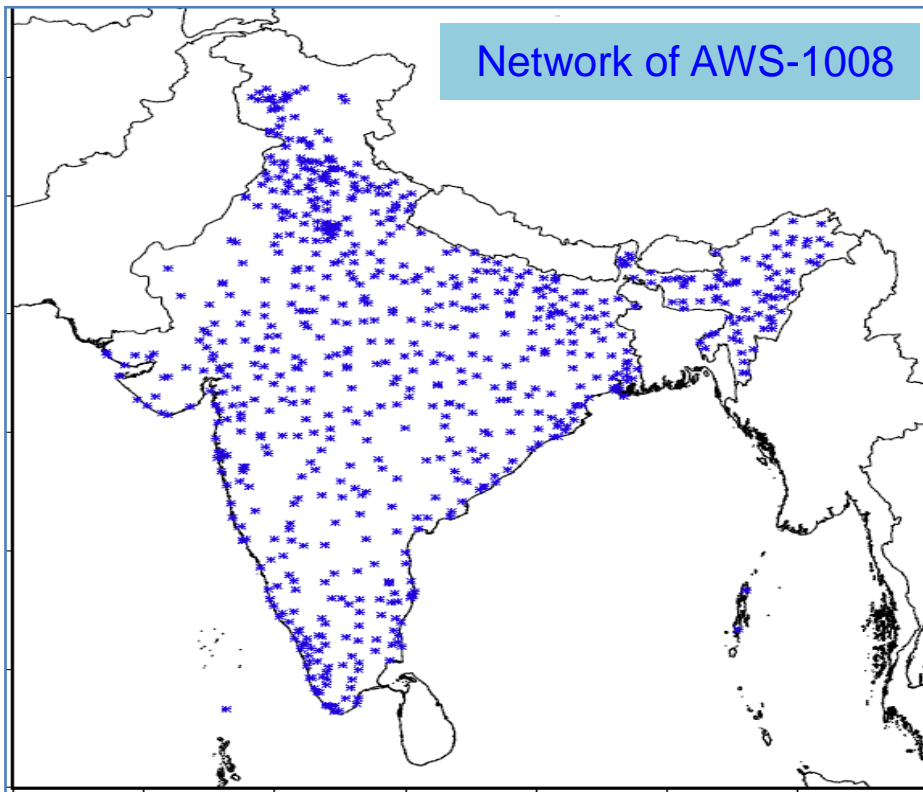
There have been significant improvements in early warning systems and weather forecasting services in India with the augmentation of observational networks, data communication systems, high-performance computing systems, modeling and forecasting systems, and warning dissemination systems. The improvement in all these aspects in recent ten years is given below :-

4.1. Observation Network

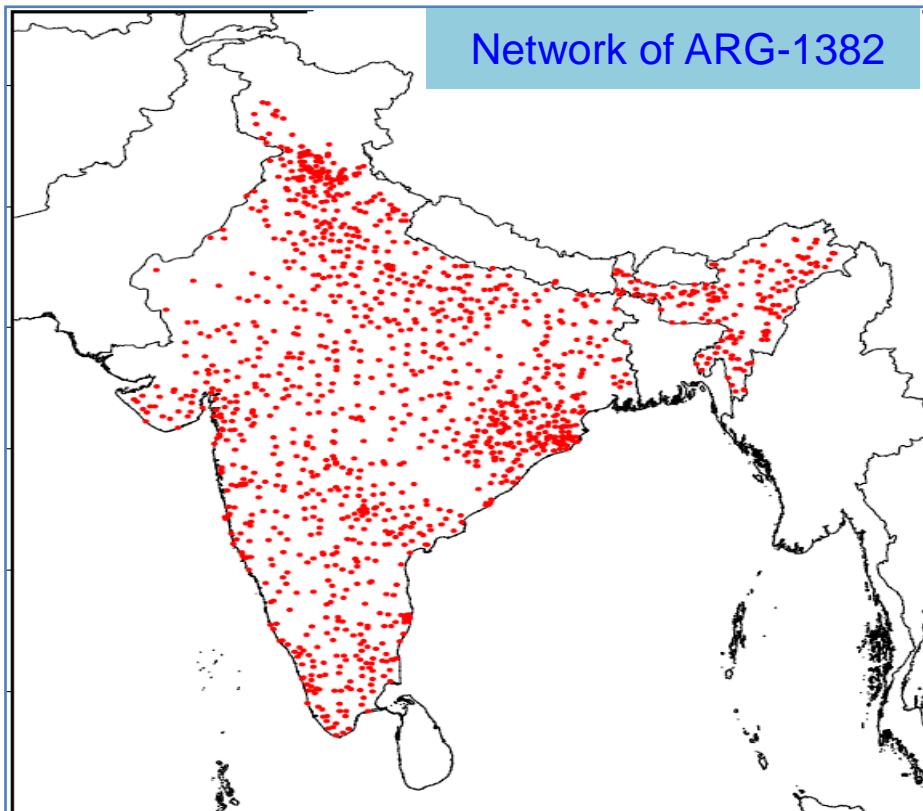
Many additional and new observatories have been introduced in the last 10 years. A comparative analysis of the same is given below.

Specification	2014	2023
Doppler Weather Radar (DWR) network	15	39
Geostationary Satellites	1 (INSAT 3D)	2 [INSAT 3D (R)]
Automatic Weather Stations (AWS)	675	1208
Automatic Rain Gauges (ARG)	1350	1382
High Wind Speed Recorders	➤ 19 ➤ Imported	➤ 37 ➤ Indigenous
Upper-Air Observation Systems		
Radio Sonde/Radio Wind Stations	➤ 43 ➤ Non GPS	➤ 56 ➤ All GPS
Pilot balloon stations	➤ 62 Total ➤ Non GPS	➤ 62 Total ➤ 23 GPS based
Airport Instruments		
Runway Visual Range (RVR) Instruments	33	156
No. of airports with RVR	12	82
Digital Current Weather Indicating Systems (DCWIS)	32	117
No. of Airports with DCWIS	21	83
Heliport Weather Observing Systems (HAWOS)	Nil	10
No. of Airports provided with weather services	74	100
Rainfall Monitoring Systems		
District-wise Rainfall Monitoring Scheme	3955	5896

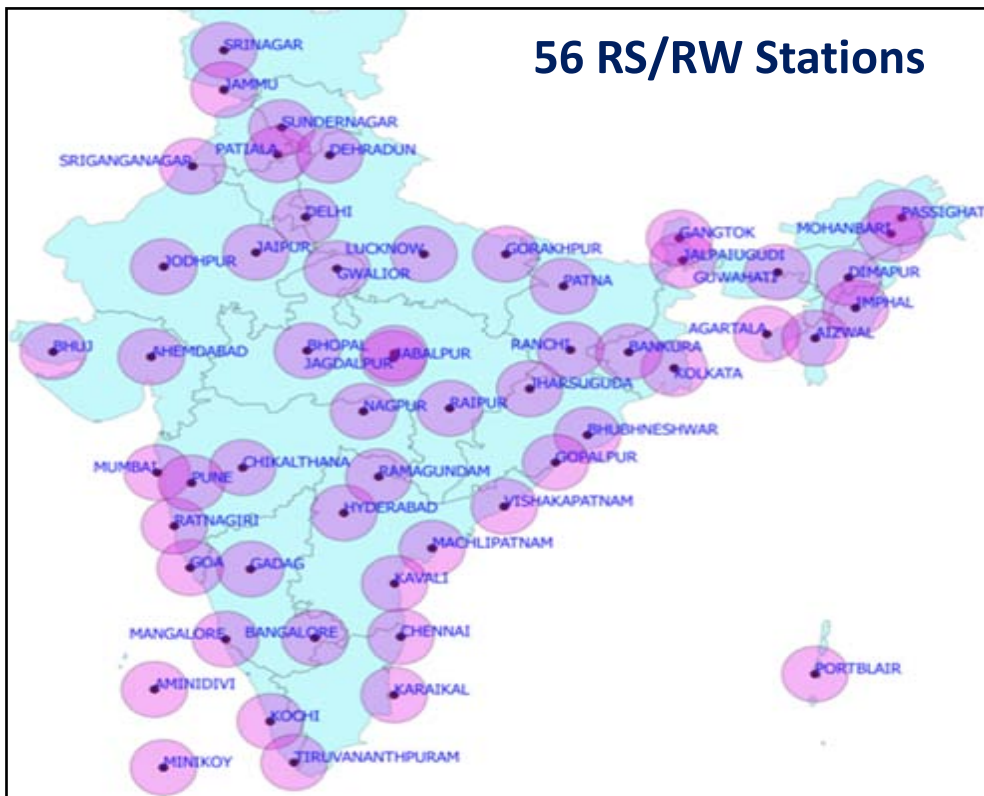
- (i) Increase in the number of **Automatic Weather Stations (AWS)** from **675 in 2014** to **1008 in 2023**.



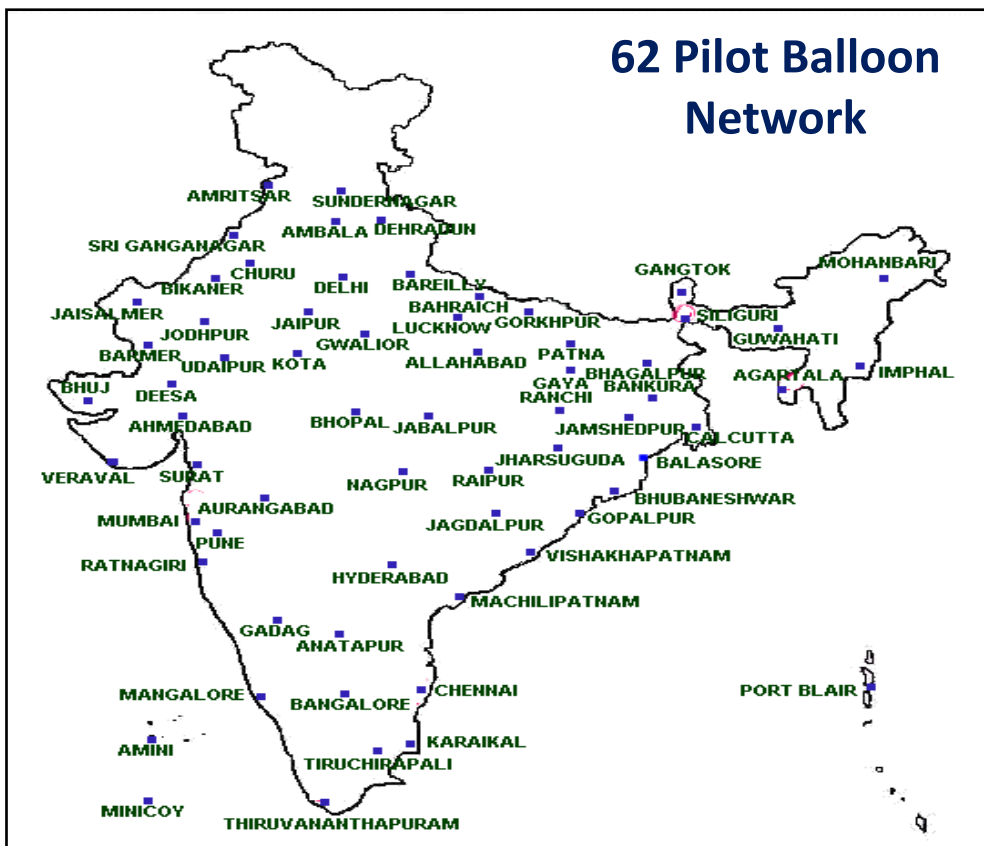
- (ii) Increase in the number of **Automatic Rain Gauges (ARG)** from **1350 in 2014** to **1382 in 2023**.



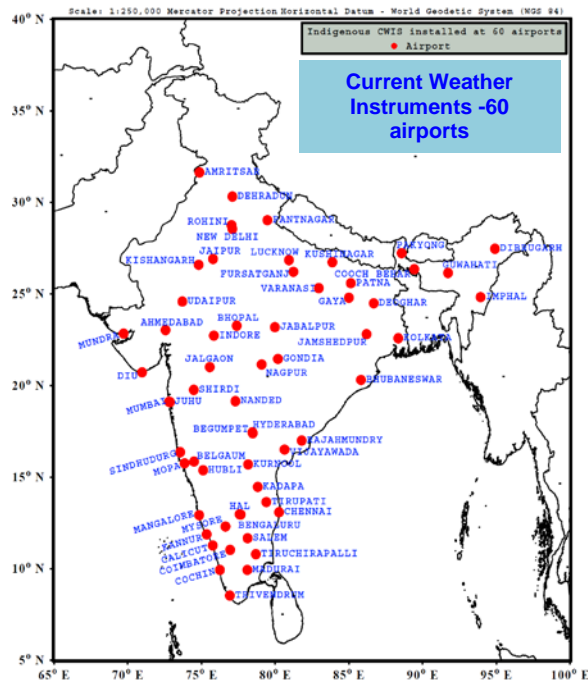
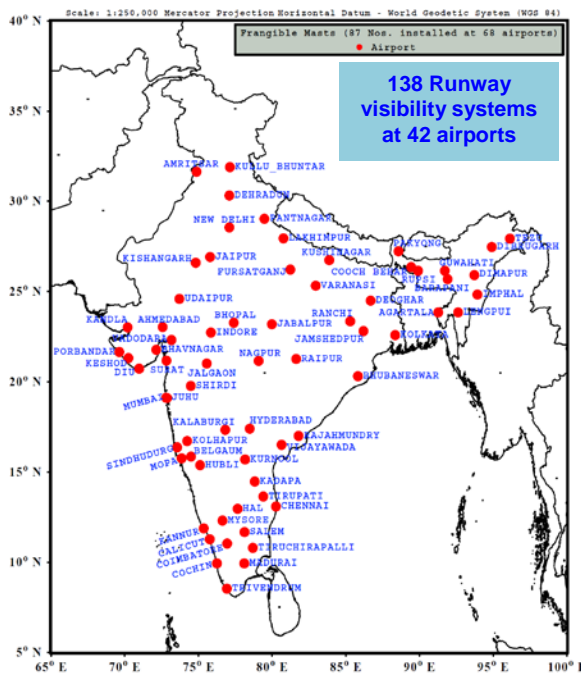
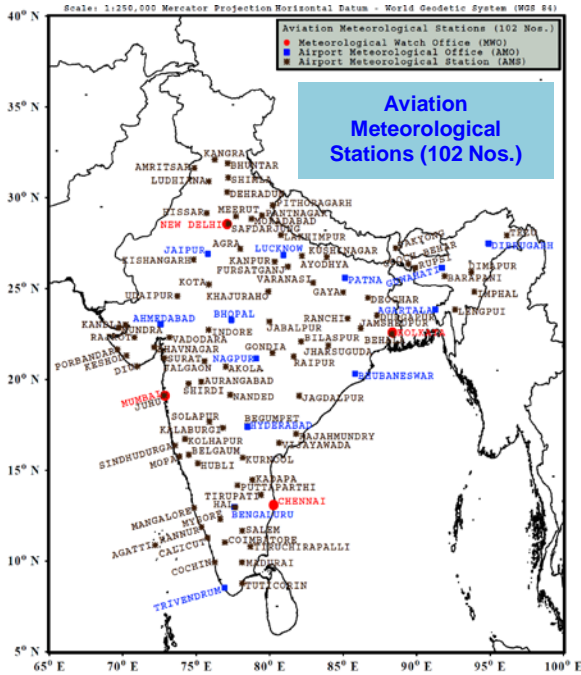
(vii) Increase in upper air observation systems from 43 in 2014 to 56 in 2023.



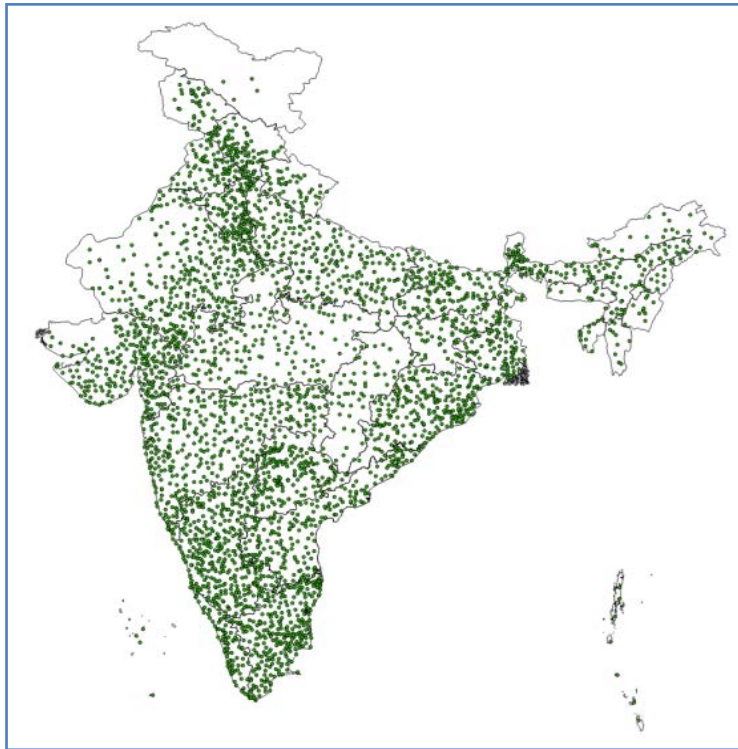
(viii) 62 PB stations 23 Manual stations upgraded to GPS-based stations while there was no GPS-based PB station in 2014.



- (ix) In the year **2014**, IMD had about **20 RVR** systems at different airports. **By 2023**, IMD has installed **138 RVR systems** at airports across the country.
- (x) Till **2014**, IMD had **Digital Current Weather Systems** at **29 airports**. **By 2023**, IMD has installed **107 Indigenous Current Weather Indicating Systems** at about **74 airports** across the country.
- (xi) **By 2023**, **8 No. of Heliport Weather Observing Systems (HAWOS)** have been installed at various heliports across the country, while there was **no HAWOS in 2014**.



- (xii) Increase in the number of **District-wise Rainfall Monitoring Scheme (DRMS)** stations from **3955 in 2014** to **5896 in 2023**.



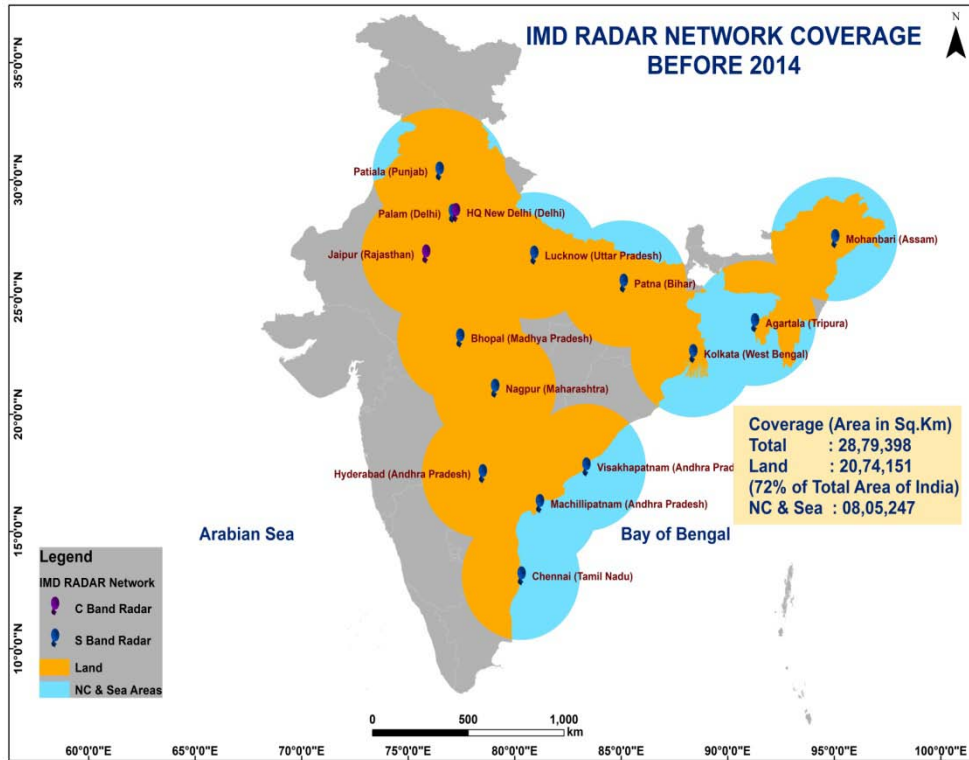
Network of **District-wise Rainfall Monitoring Scheme (DRMS)** stations - 5896

- (xiii) There are **two geostationary satellites**, viz., **INSAT-3D and INSAT-3DR in 2023** against only **one such satellite INSAT-3D in 2014**. A comparison is given below.

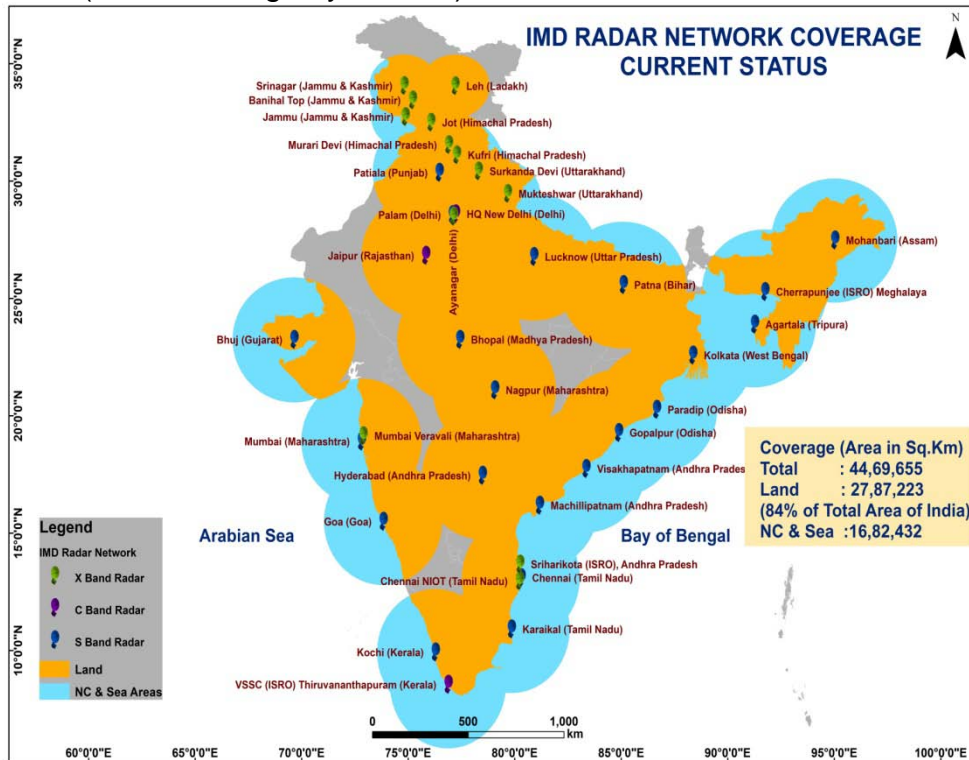
2014	2023
<ul style="list-style-type: none"> INSAT-3D (2013) Oceansat2 (Sea Surface Winds) 	<ul style="list-style-type: none"> INSAT-3D/3DR (2016) Oceansat3 (Sea Surface Winds)
<p>Temporal resolution</p> <ul style="list-style-type: none"> Half Hourly 	<p>Temporal resolution</p> <ul style="list-style-type: none"> Half hourly/15 Minutes (3D+3DR) RAPID SCAN (Less than 5 Minutes) since 2018.
<p>Derived Products</p> <ul style="list-style-type: none"> CMV/QPE/OLR/SST/UTH ((Half Hourly) Imageries for VIS/IR/WV (Half Hourly) 	<p>Derived Products</p> <ul style="list-style-type: none"> OLR/QPE/IMR/HEM/IMC/UTH/SST/LST/WDP/INS/NER/ NHC/CTBT/AET/PET/LSA/DMP/NMP/RBG/FIRE/SMOKE/ Vorticity/Shear/Convergence/Divergence OLR/SST/AOD/CTT/PPP/LST/Insolation Vertical Profile (Temperature/Humidity) Cyclone Enhancement Images

(xiv) Expansion of **Doppler Weather Radar (DWR)** network from **15 in 2014** to **39 in 2023** with land area of coverage increased by about **35%** from 2014.

2014 (Area coverage by Radars)



2023 (Area coverage by Radars)

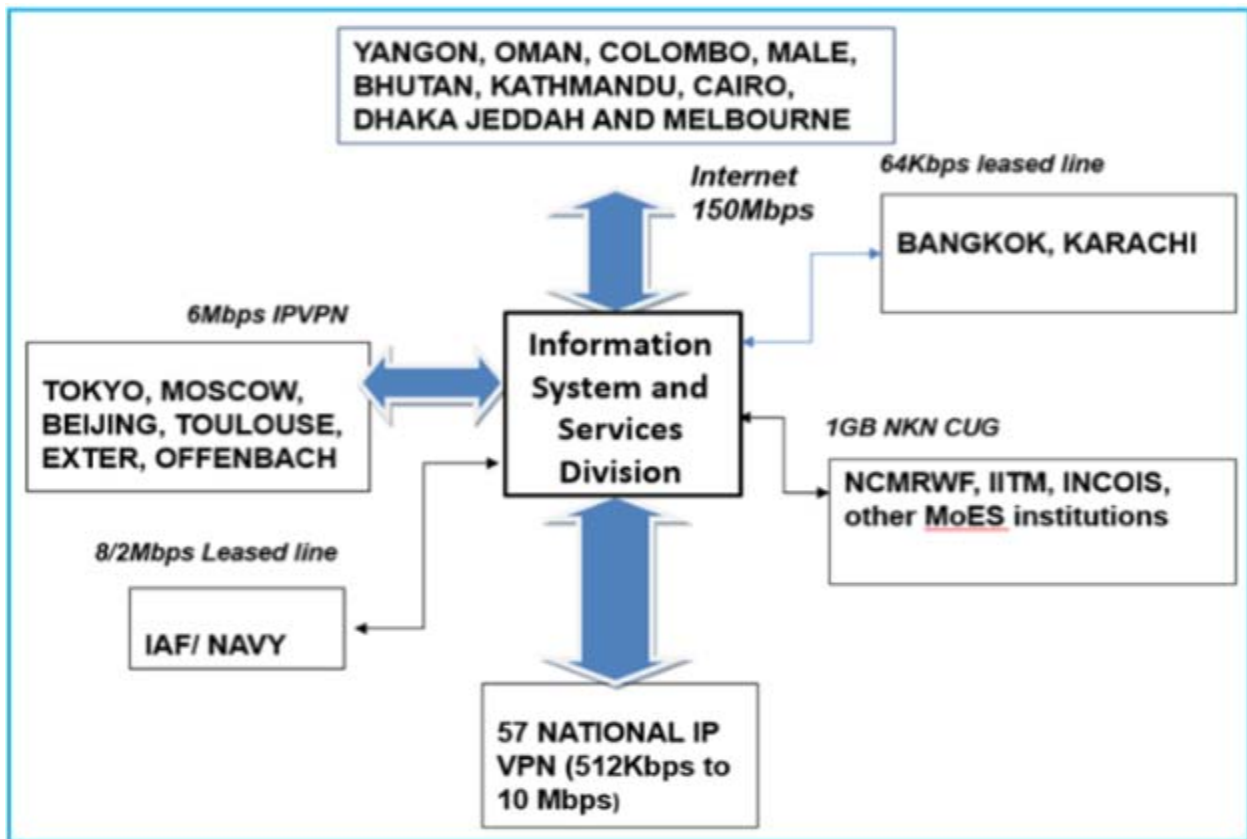


4.2 Communication

There has been significant improvement in data communication with regard to volume of data exchanged, speed, modes of communication etc in recent decade.

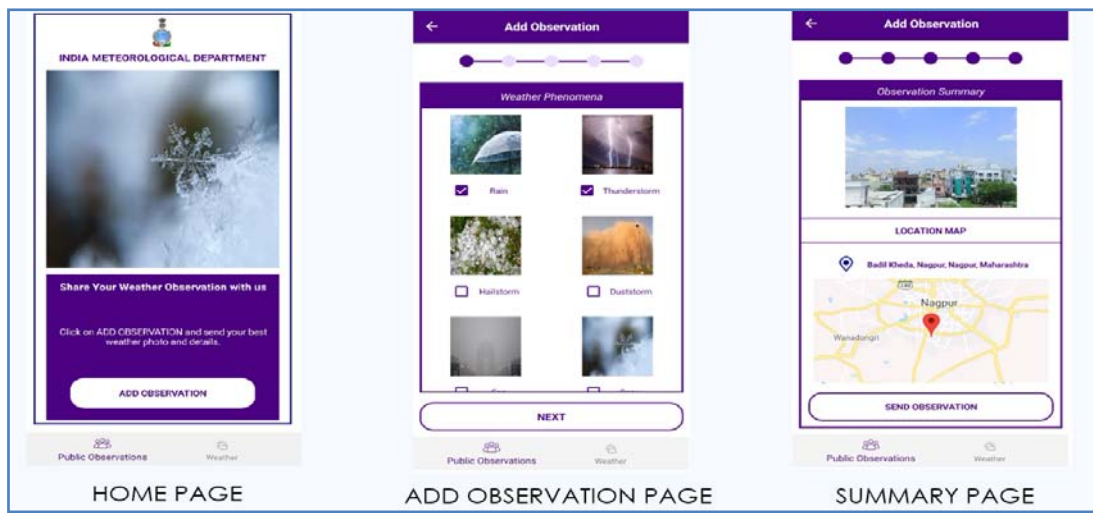
Specification	2014	2023
Data Collection	conventional method (phone, email with more manual intervention)	Manual intervention has been reduced by implementation of latest art of technology with upgrading maximum bandwidth of the order of Gbps which has reduced the time of data exchange.
Role in regional and global exchange	Regional Telecommunication Hub	Global Information Service Centre WMO Information System (WIS) WIS2.0 implemented in 2023 for regional and global exchange of data. IMD status improved from Regional to Global data dissemination centre
Internet Bandwidth	60 Mbps	1000 Mbps (16 times Increase in bandwidth)
National Data communications	8 Mbps	10 Mbps
Exchange of Data Volume/Day		
(a)Observational Data	150 MB	250 MB (1.7 times increased)
(b)Radar Data	32 GB	420 GB (14 times increased)
(c)Satellite	296 GB	1780 GB (6 times increased)
(d)NWP	300 GB	2500 GB (8.2 times increased)
Data collection through Public Involvement	No facility	Crowd Sourcing implemented in 2021
Common Alerting Protocol	Nil	For cyclone alerts and other severe weather warnings since 2022.
Forecast and Warning Dissemination	Conventional methods, Web site and SMS only	<ul style="list-style-type: none"> • Weather Apps such as Meghdoot, Mausam, Damini, • Social media platforms like Facebook, Twitter, WhatsApp, YouTube, Instagram etc. • Daily/weekly weather video. • Dedicated websites for different purposes like cyclone, severe weather, climate, etc • APIs for various weather observations and forecast products used by more than 60 government and private organizations

Data Communication Framework for two ways exchange of data



Crowdsourcing

- India Meteorological Department launched its Crowdsourc web interface in January 2021 and the mobile App "Public Observation" on 14th January, 2022 to allow users to provide their weather feedback at anytime from anywhere.
- IMD launched its crowd-sourcing mechanism through web interface to collect all observed weather phenomena like rain, thunderstorm, squall etc., from public which were not available till 2014.



4.3 Numerical Weather Prediction Models

IMD/MoES runs a seamless modelling system to cover forecasts at all time scales from a few hours to a season as mentioned below. At present 7 NWP models are run for the products generated for day-to-day forecasting covering timescales from MoES Institutions like NCMRWF, Noida; IITM, Pune; INCOIS Hyderabad, etc from Nowcasting to seasonal forecast as given below.

- Nowcast to Very Short Range (up to 3 to 12 hrs)
- Short Range (Up to 3 days)
- Medium Range (Up to 10 days)
- Extended Range (Up to 4 weeks)
- Seasonal forecast (Up to a season)

There has been a paradigm shift in types of Models, Model Resolution, Lead period, Update frequency, Model products prepared, volume of data and products for different sectoral applications in the last 10 years.

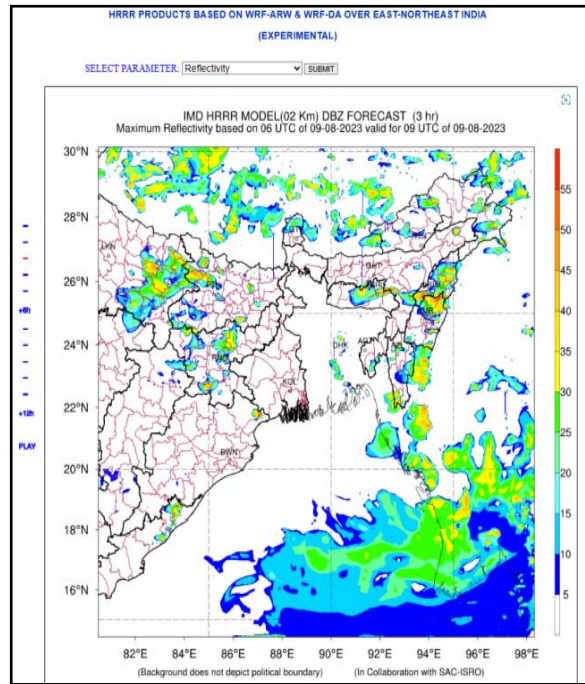
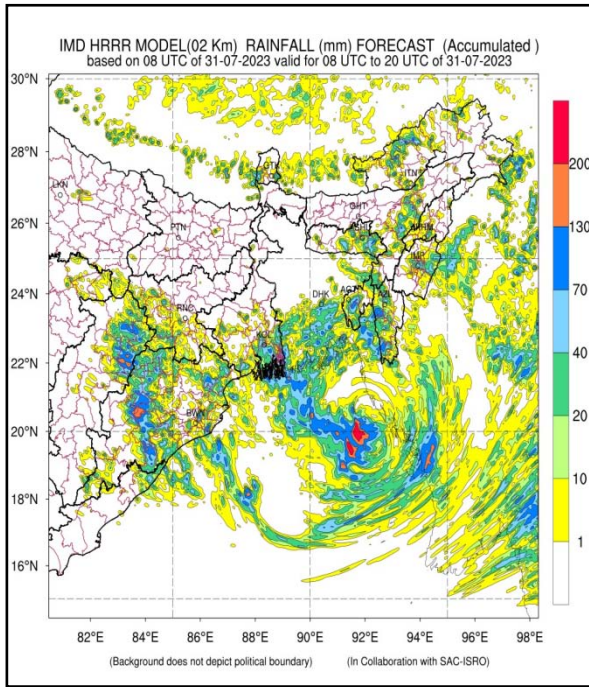
Models	2014	2023
Nowcast model For very short-range forecast (Up to 12 hrs)	Not available	<ul style="list-style-type: none"> • Electric WRF (EWRf) model at 3 km with lightning data assimilation • High-Resolution Rapid Refresh (HRRR) at 2 km with Radar data assimilation
Regional model For short range (3 days forecast)	<ul style="list-style-type: none"> • Resolution- 9 km • Forecast period – 3 days • Run 2 times a day 	<ul style="list-style-type: none"> • Resolution- 3 km (3 times) • Forecast period – 3 days • Run 4 times a day
Global Model for medium-range deterministic forecast	<ul style="list-style-type: none"> • Resolution- 25 km • Data assimilated – 50 GB per day • Forecast period – 5 days • Run 2 times a day • Guidance products - 59 	<ul style="list-style-type: none"> • Resolution- 12 km (2 times) • Data assimilated – 500 GB per day (10 times increase) • Forecast period – 10 days • Run 4 times a day • Guidance products – 84 (42% increase)
Coupled Hurricane WRF (HWRF) model for cyclone	<ul style="list-style-type: none"> • Resolution- 27x9 km • Forecast period – 3 days • No Ocean model 	<ul style="list-style-type: none"> • Resolution- 18x6x2 km • Forecast period – 5 days • With coupled ocean model
Global ensemble model for medium-range probabilistic forecast	Not available	<ul style="list-style-type: none"> • Resolution- 12 km • Forecast period – 10 days • Run 2 times a day
Multi-model ensemble (MME)	For cyclone track only	<ul style="list-style-type: none"> • MME for cyclone track, intensity, landfall point & landfall time. • MME-based forecast based on 7 global model outputs • Seven variables : Rainfall, temperature, wind direction,

		<p>wind speed, humidity, cloud cover</p> <ul style="list-style-type: none"> • For 7 days • At Met-subdivision, district, river basin, city and block level.
Extended Range Model up to 4 weeks	Not available	<ul style="list-style-type: none"> • Since 2017 : to provide forecasts for the next 4 weeks for cyclogenesis, rainfall and temperature, wind, MJO etc • This is developed through the Monsoon Mission program of MoES through collaborative efforts of IITM, NCMRWF, INCOIS and IMD, which is operational at IMD. • Run on the fly with hindcast for 20 years (2003-2022) • Run for 32 days with the weekly update • Sectoral application products available for : Agriculture, Water, Disaster Risk Reduction, Power and Health
Dynamical monthly and seasonal forecast	Not available	The forecast is updated every month for the next month and next season.
NWP Data supplied to users	37.62 TB	97.3 TB (2.5 times increase)

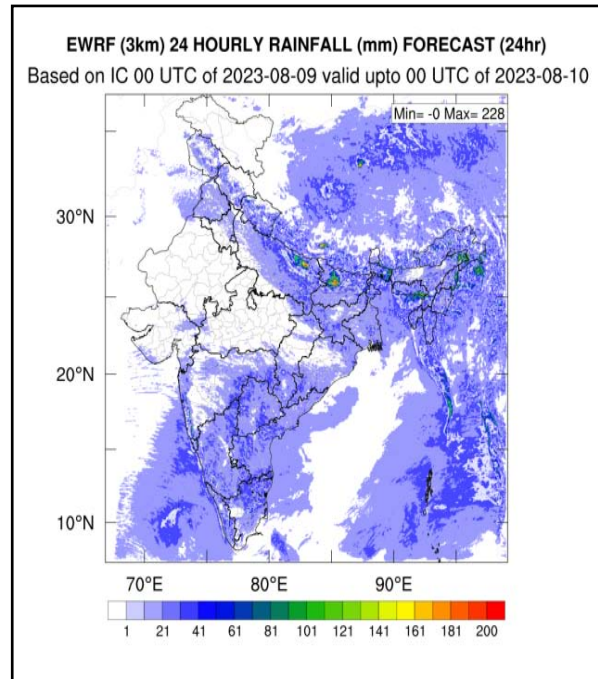
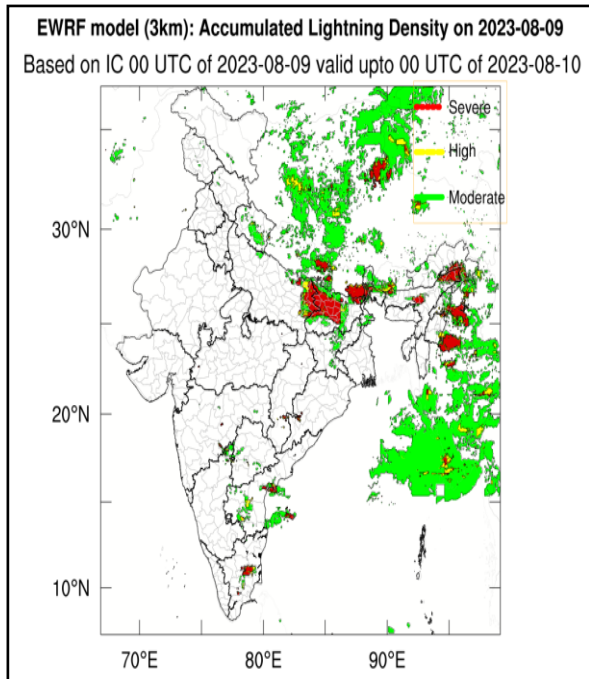
Operational NWP models in as on January 2024 (Nowcast to Extended Range Forecast)

Temporal scales	Operational Numerical NWP/Climate Models	Resolutions and Frequency of Update
Nowcasting to short range forecasting	<ul style="list-style-type: none"> • Weather Research Forecast (WRF) regional models • HRRR (with radar data assimilation) • E-WRF (with lightning data assimilation) • Coupled Hurricane WRF (HWRF) 	<ul style="list-style-type: none"> • 03 km run for 3 days (Run 4 times a day) 00, 06, 12 & 18 UTC • Run for 3 domains, 2 km resolution with forecast for 12 hours. (every 2 hrs) • Run 2 times a day (2 km Resl. 24 hr forecast • 18x6x2 km (During cyclone time) for 5 days
Medium range forecast	<ul style="list-style-type: none"> • Global Forecast System (GFS) Model • Global Ensemble Forecast System (GEFS) 	<ul style="list-style-type: none"> • 12 km (Run four times a day ; 00, 12 UTC) for 10 days and 06 & 18 for 3 days • 12 km (00 UTC) for 10 days; 20 Members
Extended range (ERF)	<ul style="list-style-type: none"> • Climate Forecast System (CFS) coupled models (16 members) with hidcasts of 20 Years (2003-2022). 	<ul style="list-style-type: none"> • 38 km (Run once in a week) for 32 days. Run based on every Wednesday and forecast is prepared for 4 weeks.
Multi-Model Ensemble (MME)	<ul style="list-style-type: none"> • MME forecast based on 6 Global models. (IMD-GFS, IMD-GEFS, NCEP-GFS, NCUM, JMA and ECMWF) • MME based track & intensity with 8 models – IMDGFS, ECMWF, NCEP, NCUM-G, NCUM-R, HWRF, UKMO, ECC 	<ul style="list-style-type: none"> • Regridded into 12km x12km and customized products are prepared based on all 6 models for 7 days. • Prepared during the cyclone time and used for operational forecast.

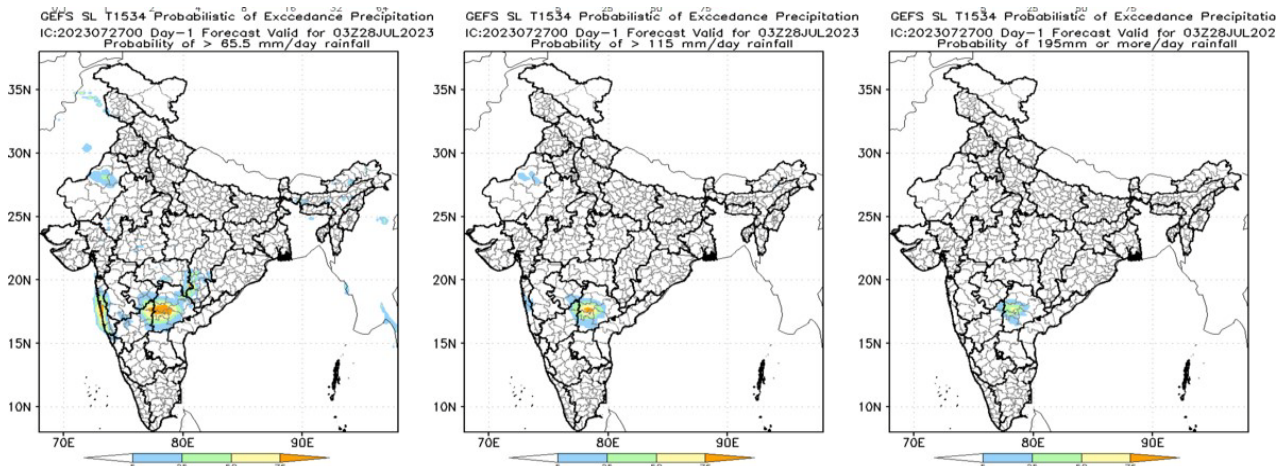
High-Resolution Rapid Refresh (HRRR) model for Nowcasting of Rainfall & Reflectivity forecasts



EWRF model for Nowcast of Lightning density & Accumulated Rainfall forecasts



Global Ensemble Forecast System (GEFS) day -1 forecast products (available through joint efforts of IITM, Pune; NCMRWF Noida and IMD) with the probability of different rainfall thresholds (65.5 mm, 115 mm and 195 mm/day)



Rainfall accumulated over 24 hours valid for 03 UTC of 28 July 2023 based on GEFS model forecast based on 00 UTC of 27 July 2023.

MME Based Met sub-division wise (36) rainfall intensity forecast for 7 days

NUMERICAL WEATHER PREDICTION DIVISION

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Please check the Date of Rainfall Intensity Forecast as different Models has different updation time

DAY-01 SUB-DIVISION HEAVY RAINFALL FORECAST

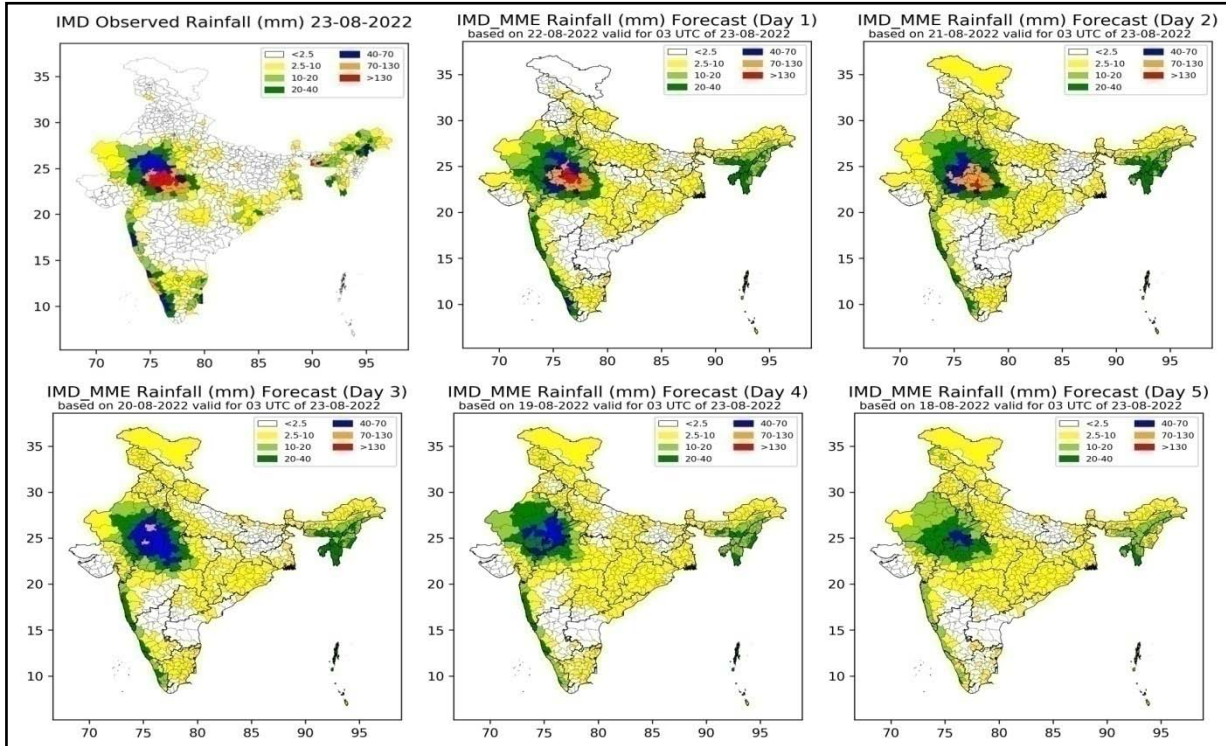
S.NO.	SUB-DIVISION	BASED ON:00Z09082023	BASED ON:00Z09082023	BASED ON:00Z09082023	BASED ON:00Z09082023	BASED ON:00Z09082023	BASED ON:00Z09082023	BASED ON:00Z09082023	BASED ON:00Z09082023
		:VALID FOR:10082023	:VALID FOR:10082023	:VALID FOR:10082023	:VALID FOR:10082023	:VALID FOR:10082023	:VALID FOR:10082023	:VALID FOR:10082023	:VALID FOR:10082023
		GFS MEAN(MAX)	JMA MEAN(MAX)	NCUM MEAN(MAX)	NCEP_GFS MEAN(MAX)	GEFS MEAN(MAX)	NEPS MEAN(MAX)	ECMWF MEAN(MAX)	MME MEAN(MAX)
01	A & N ISLAND	7 (24)	4 (9)	8 (21)	7 (15)	7 (14)	9 (13)	6 (20)	6 (16)
02	ARUNACHAL PRADESH	17 (225)	10 (119)	18 (274)	15 (151)	11 (81)	17 (66)	22 (91)	17 (147)
03	ASSAM & MEGHALAYA	16 (89)	6 (30)	17 (147)	19 (93)	13 (65)	15 (73)	11 (56)	15 (85)
04	N M M T	19 (131)	12 (79)	11 (75)	14 (60)	17 (75)	11 (42)	11 (48)	13 (71)
05	SHWB & SIKKIM	15 (86)	15 (82)	14 (76)	7 (18)	9 (31)	12 (29)	10 (48)	15 (57)
06	GANGETIC WEST BENGAL	4 (15)	17 (48)	7 (32)	5 (16)	5 (12)	8 (23)	9 (33)	9 (31)
07	ORISSA	3 (43)	1 (10)	3 (15)	3 (19)	3 (27)	4 (21)	2 (14)	2 (21)
08	JHARKHAND	5 (22)	11 (78)	6 (36)	5 (28)	7 (18)	9 (41)	6 (45)	6 (41)
09	BIHAR	10 (41)	27 (78)	24 (328)	19 (92)	14 (32)	26 (64)	25 (114)	19 (101)
10	EAST UTTAR PRADESH	34 (281)	16 (46)	29 (403)	11 (88)	28 (74)	21 (88)	29 (504)	23 (174)
11	WEST UTTAR PRADESH	3 (48)	4 (28)	5 (191)	3 (19)	5 (28)	6 (101)	2 (20)	4 (61)
12	UTTARAKHAND	11 (91)	12 (74)	11 (99)	10 (29)	8 (42)	12 (67)	6 (32)	10 (66)
13	HAR. CHD & DELHI	1 (2)	1 (3)	2 (14)	2 (5)	1 (25)	2 (6)	1 (4)	1 (8)
14	PUNJAB	3 (29)	1 (4)	4 (22)	1 (6)	3 (20)	3 (14)	5 (18)	3 (18)
15	HIMACHAL PRADESH	3 (50)	1 (8)	3 (54)	2 (9)	3 (33)	3 (15)	2 (10)	2 (25)
16	JAMMU AND KASHMIR	1 (69)	1 (31)	1 (50)	1 (6)	1 (21)	1 (21)	1 (9)	1 (38)
17	WEST RAJASTHAN	1 (4)	1 (1)	1 (3)	1 (2)	1 (6)	1 (1)	1 (3)	0 (2)
18	EAST RAJASTHAN	1 (4)	1 (7)	1 (4)	1 (3)	1 (3)	1 (4)	1 (10)	0 (4)
19	WEST MADHYA PRADESH	1 (4)	1 (6)	2 (13)	1 (4)	1 (4)	2 (8)	2 (13)	1 (6)
20	EAST MADHYA PRADESH	1 (22)	1 (4)	2 (5)	1 (3)	2 (27)	3 (11)	2 (4)	1 (11)
21	GUJARAT REGION	2 (6)	4 (12)	2 (7)	2 (5)	2 (7)	2 (5)	3 (7)	2 (7)
22	SAURASHTRA & KUTCH	2 (4)	2 (7)	1 (2)	2 (3)	2 (4)	1 (3)	2 (6)	1 (4)

Rainfall Intensity :
Mean (Maximum) rainfall over the subdivision for 7 days based on 7 NWP models and MME with different colour indicating different rainfall intensity.

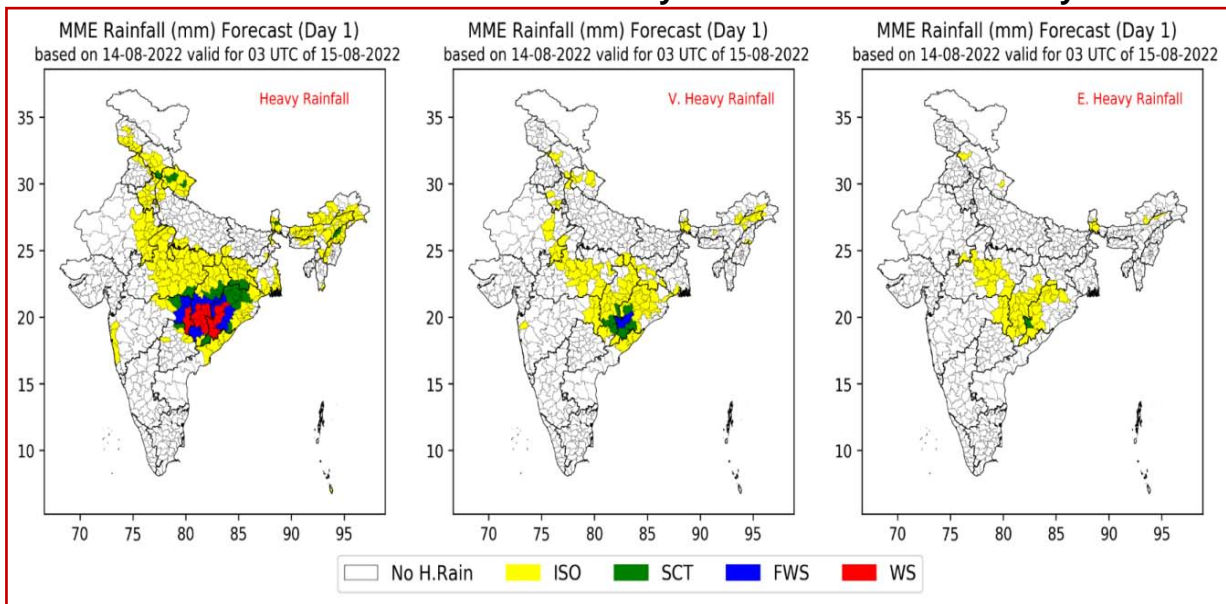
AMOUNT	CATEGORY	AMOUNT	CATEGORY
NIL	NO RAIN	64.5-115.5	HEAVY
1-15	LIGHT	115.6-204.4	VERY-HEAVY
15.1-64.4	MODERATE	>=204.5	EXTREMELY-HEAVY

- **The MME forecasts** products in the medium-range time scales are also generated for Indian cities, districts, meteorological sub-divisions, Indian coastal regions, and the North Indian Ocean for various applications, such as : for general weather forecasting, severe weather forecasting, for issuing Agro-advisory.
- MME-based forecast products are also generated for entire RSMC domains, covering India along with neighbouring countries and also the north Indian Ocean, river basins, Sea areas, fleet areas etc. These forecast products are also used for the automation of different weather bulletins.

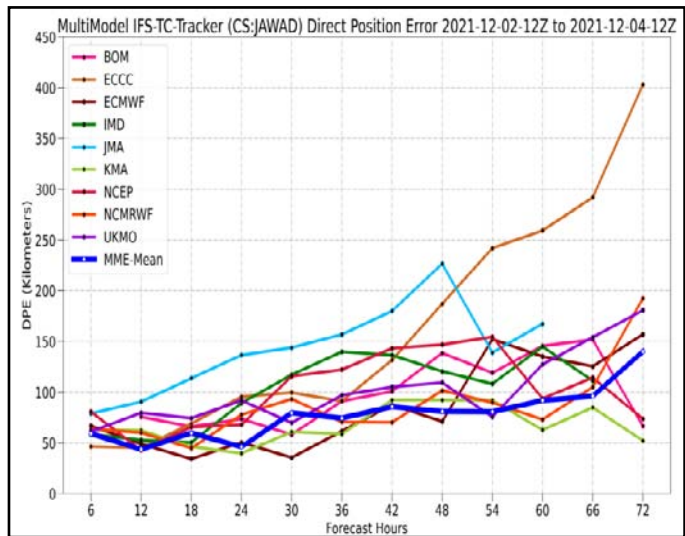
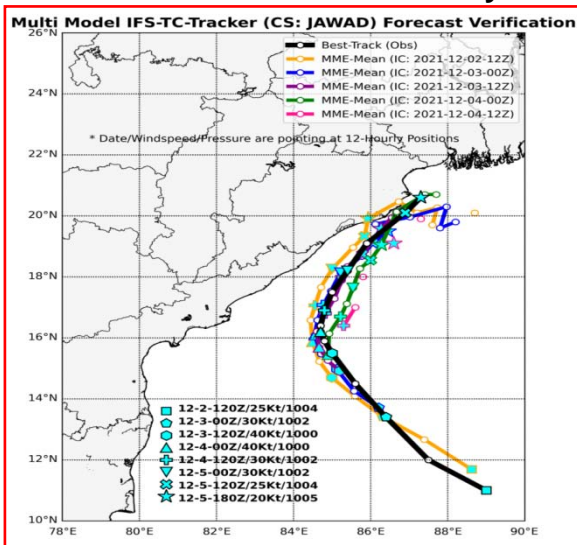
MME based district scale mean rainfall forecast for 5 days



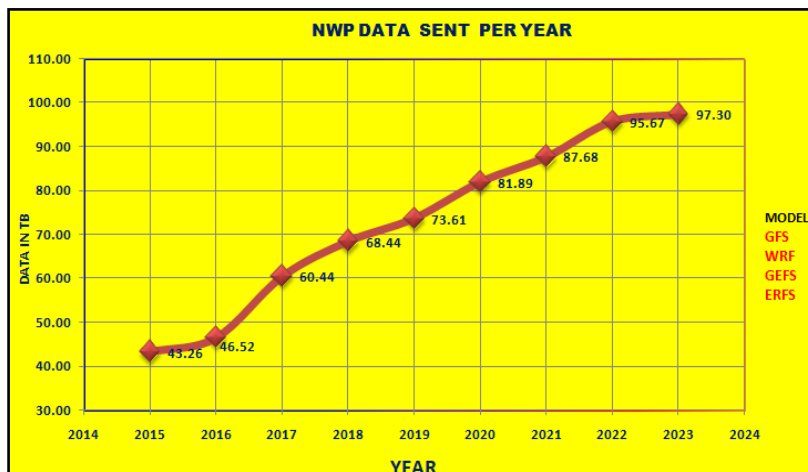
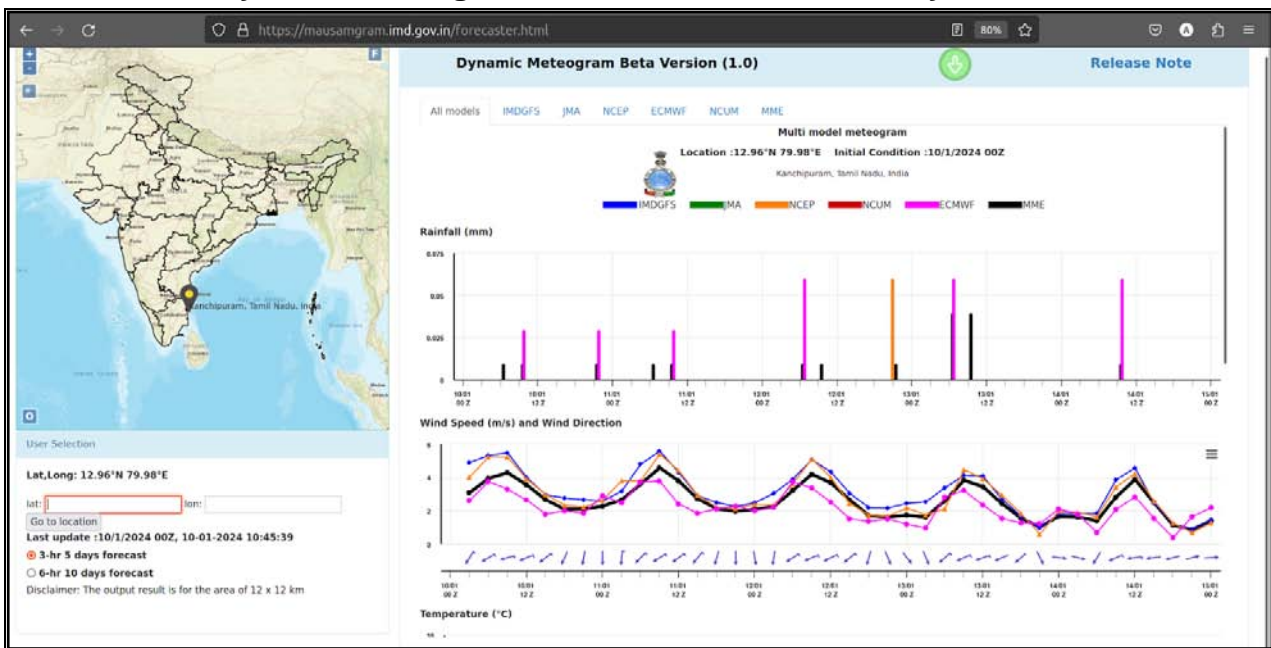
MME based district scale for Heavy Rainfall forecast for 5 days



MME-based cyclone track and intensity forecast

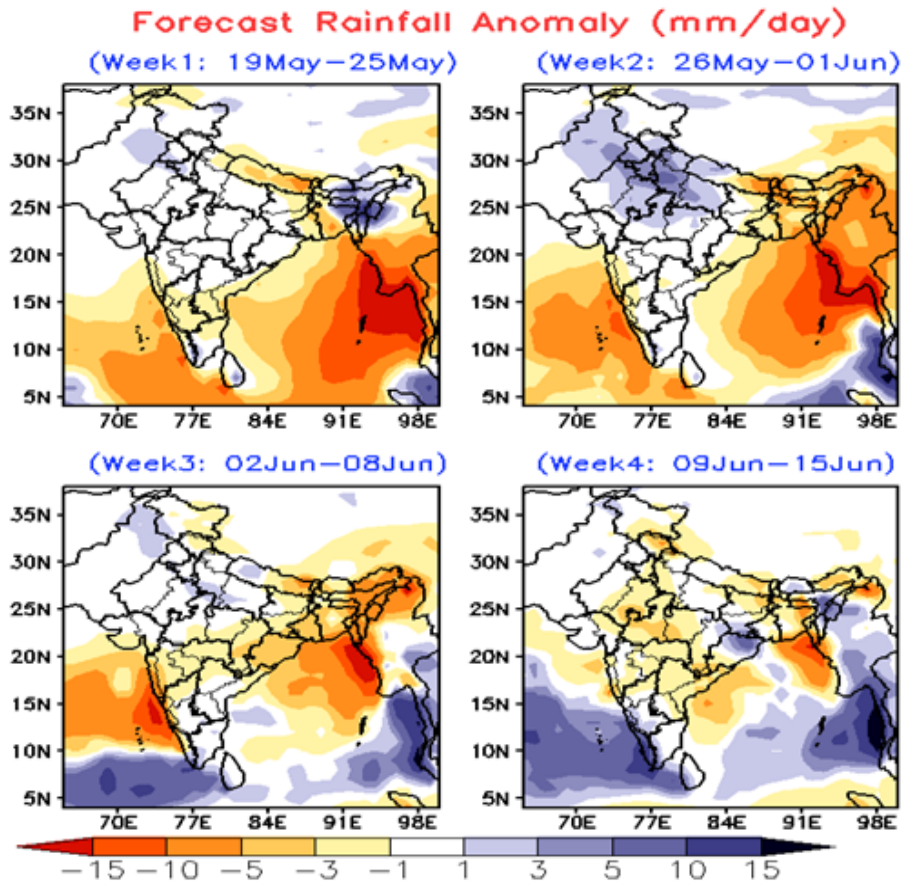
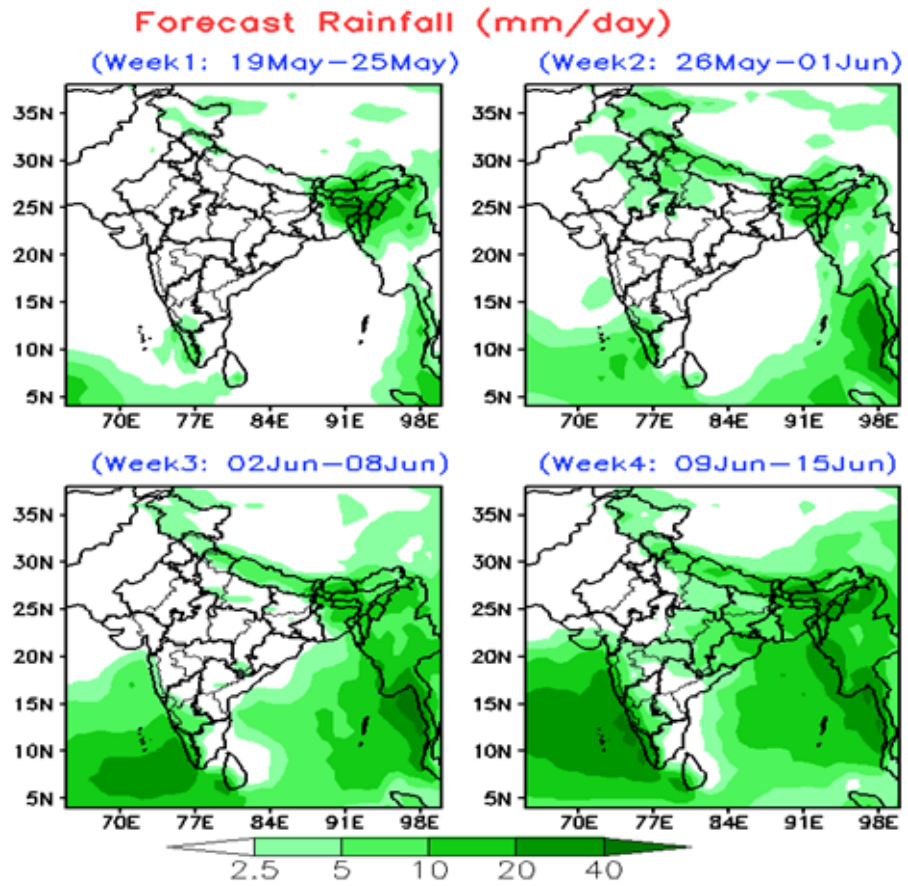


Dynamic Meteogram for weather forecast at any location



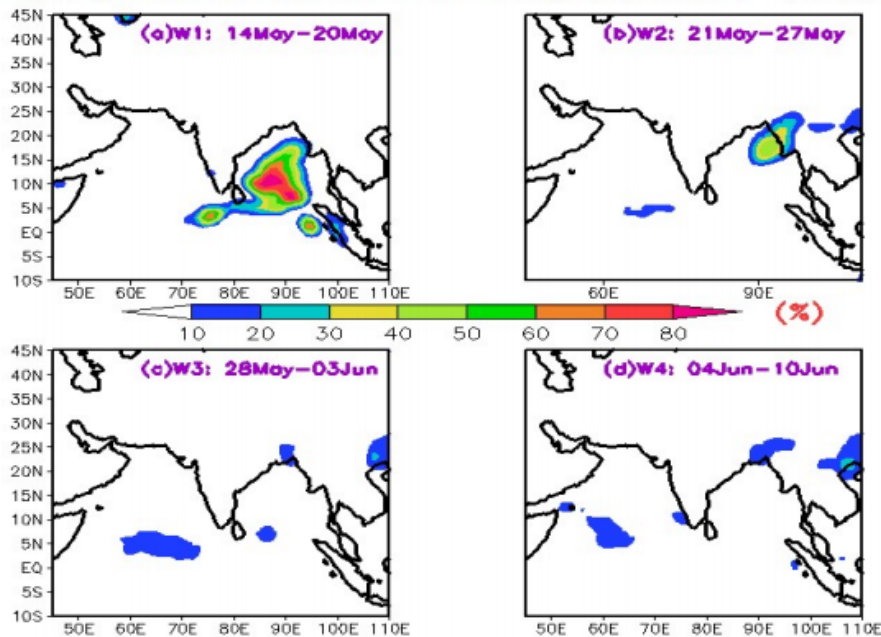
The volume of NWP data supplied to various research communities, State Emergency Operation Centres (SEOCs) and National Meteorological and Hydrological services of different countries has increased manifold in the last decade.

**Extended range forecast (ERF) of rainfall and its anomaly for 4 weeks
(IC : 17 May 2023)**

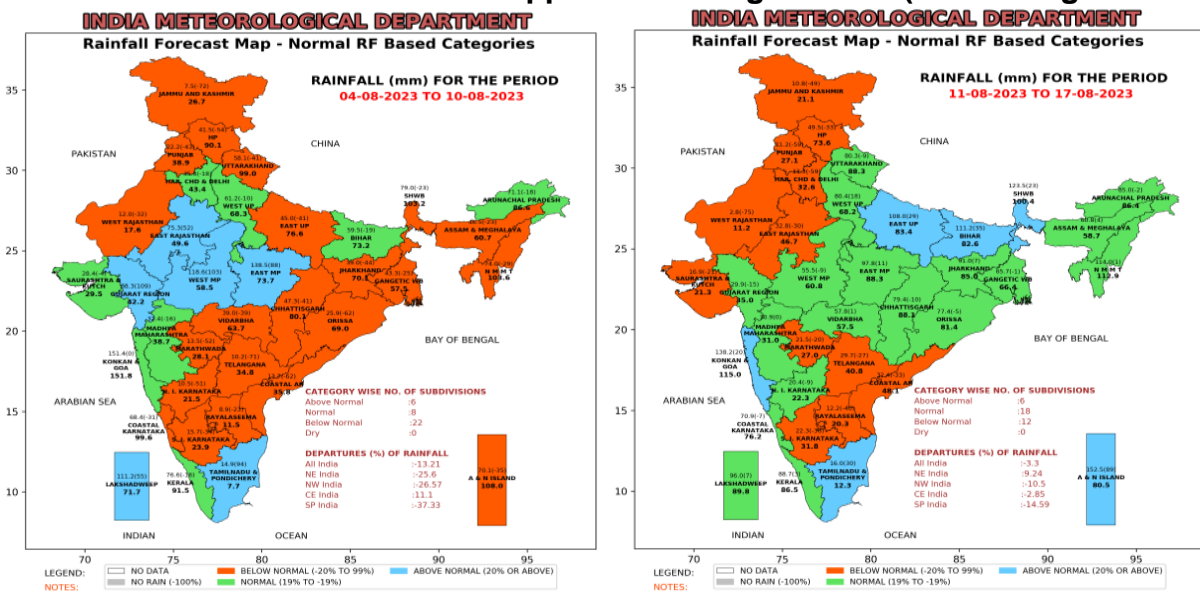


Cyclogenesis probability forecast for 4 weeks (IC : 12 May 2020)

Cyclogenesis & Evolution Probability (%), IMDERF (MME)



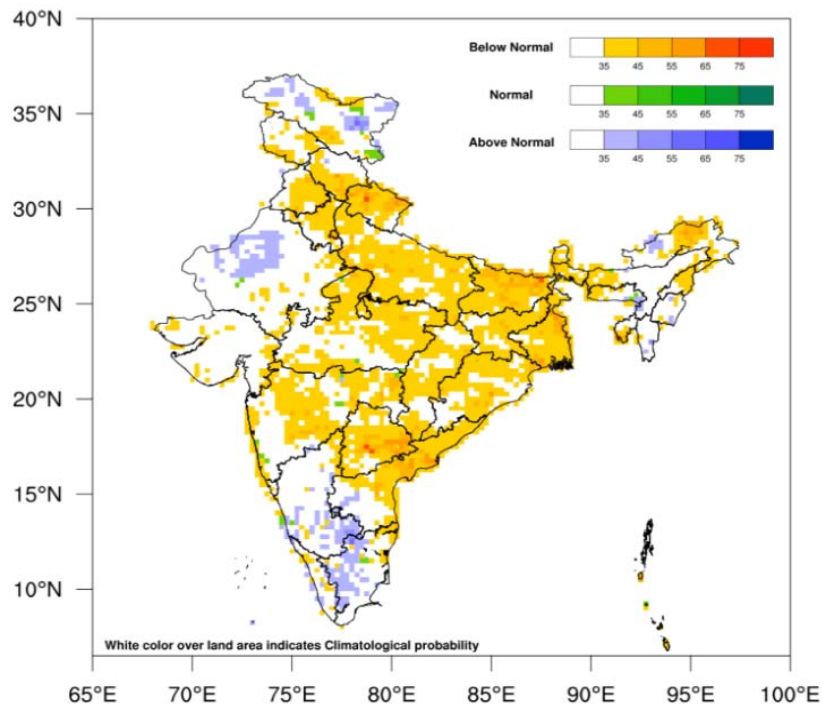
Sub-division level ERF rainfall for application in Agriculture (IC : 02 August 2023)



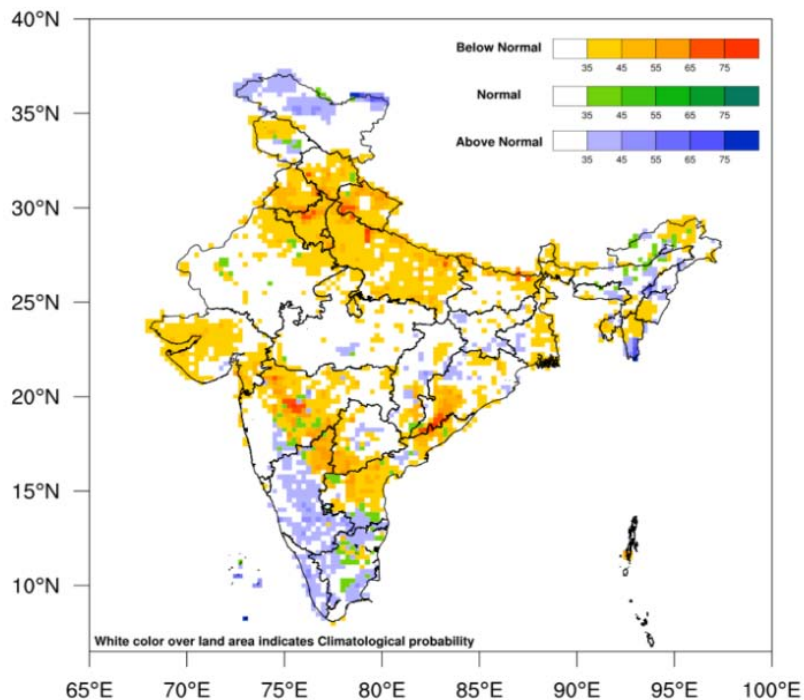
4.4 Monthly and Seasonal Forecast

The updated forecast for monthly forecast for June 2023 and seasonal rainfall forecast for June-September, 2023 based on the Multi-Model Ensemble (MME) by using MMCFS (Monsoon Mission Climate Forecast System) climate model and best few climate models that have the highest forecast skills over the Indian monsoon region.

Probability Monthly Rainfall Forecast for June 2023 (May ICs)



Tercile Probability of seasonal monsoon rainfall forecast for Jun-Sep 2023 (May ICs)



4.5 Weather Forecasting and Warning Services

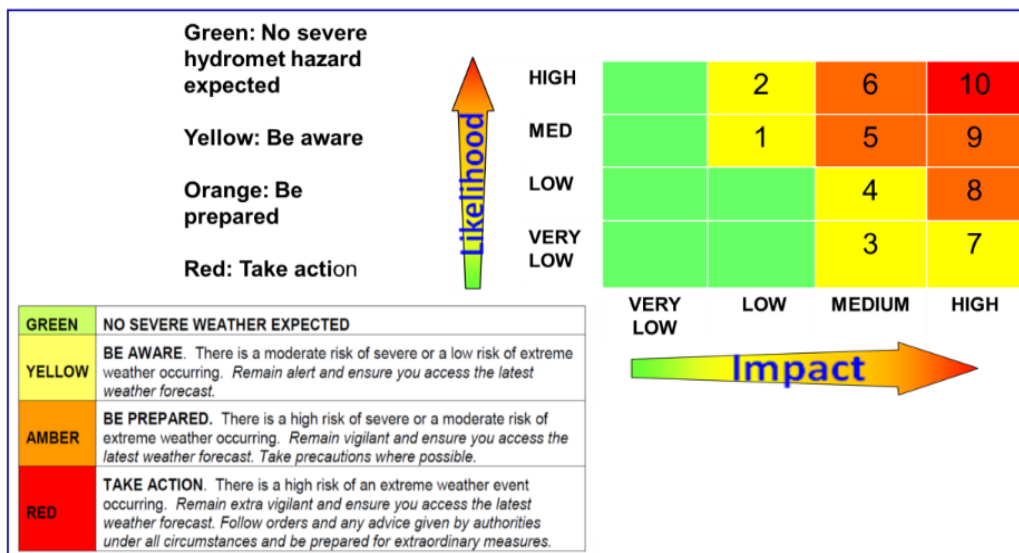
Overall Forecast Accuracy improvement: 40% improvement in 2023 as compared to 2014.

IMD implemented Impact Based Forecast (IBF) in recent years at the district level since 2020. It contains the details of impacts expected from the severe weather elements

and guidelines to the general public about do's and don'ts. These guidelines are finalized in collaboration with the National Disaster Management Authority (NDMA) and have already been implemented successfully for cyclones, heatwaves, thunderstorms, and heavy rainfall. Work is in progress to implement the same for other severe weather elements.

While issuing the warning suitable colour code is used to bring out the impact of the severe weather expected and to signal the Disaster Management about the course of action to be taken concerning impending disaster weather events. **The green colour corresponds to no warning hence no action is needed, the yellow colour corresponds to being watchful and getting updated information, the orange colour suggests to be alert and be prepared and the red colour advises taking action.**

- Impact-based Forecasting (IBF) is being issued for all severe weather events at district and city levels with the inclusion of exposure and vulnerability parameters and suggestions for necessary actions.



4.6 Tropical Cyclone Forecasting Services

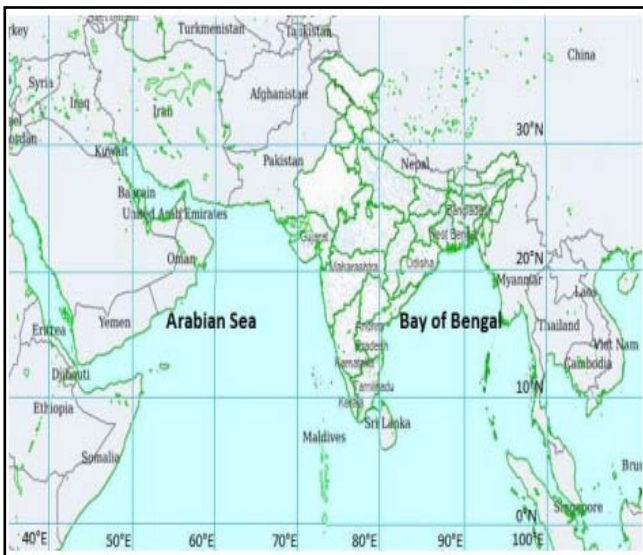
Cyclone Forecast	
First-ever initiatives	<p>First-time ever Initiatives:</p> <ul style="list-style-type: none"> (i) probabilistic forecast of cyclogenesis for the next three days in 2014, the next five days in 2018 and the next 7 days in 2023. (ii) extended range forecast of cyclogenesis upto two weeks in 2018, (iii) Pre-genesis track and intensity forecast of cyclone on the formation of a low-pressure area in 2022 against similar forecast only after the formation of deep depression before 2014. The first country in the world to provide track & intensity forecast from low-pressure stage (iv) cyclone track and intensity forecast in GIS for the public, disaster managers and other stakeholders, (v) Dynamic impact-based forecast (IBF) utilising Web GIS-based Dynamic Composite Risk Atlas (Web-DCRA) in 2021 enabling risk assessment at the village level against IBF based on historical

	<p>damage database at the district level,</p> <p>(vi) Customised location-specific impact-based forecast for onshore and offshore industries, fishermen, ports, coastal and high sea shipping in 2022 against textual messages before 2014.</p> <p>(vii) Introduction of dedicated website for cyclones (2014), SMS to disaster managers (2012), SMS to general public, fishermen & farmers (2014), social media (2016), SMS, NaViC (2021), mobile apps(2020), bulletins transmission through WhatsApp (2020), Common Alerting protocol(2022), video messages in English, Hindi & regional languages (2022) for cyclone warning.</p>	
Death Toll	<p>Odisha Super Cyclone caused 10,000 deaths in 1999 in India</p> <p>The Bholia Cyclone caused 300,000 deaths in 1970, Nargis cyclone caused 1,25,000 deaths in Myanmar in 2008</p>	<p>The death toll has reduced significantly to double digits not only in India but also in 13 WMO/ESCAP Panel Member countries bordering the Bay of Bengal and the Arabian Sea.</p> <p>Graphics</p>
Error in the track forecast	<p>2005-2013: 24 hours ahead: 126 km 48 hours ahead: 200 km 72 hours ahead: 268 km</p>	<p>2014-22 : 24 hours ahead: 78 km (38% improvement) 48 hours ahead: 120 km (41% improvement) 72 hours ahead: 169 km (36% improvement)</p>
Error in intensity forecast	<p>2005-2013: 24 hrs ahead: 11.4 kts 48 hrs ahead: 14.3 kts 72 hrs ahead: 17.6 kts</p>	<p>2014-22 : 24 hrs ahead: 8.3 kts (27% improvement) 48 hrs ahead: 11.9 kts (16% improvement) 72 hrs ahead: 14.3 kts (18% improvement)</p>
Landfall point	The 72hr landfall point forecast error in five years (2019-2023) is 73 km compared to that of 104 km in the five years (2014-2018)	
Comparison with global centres		In comparison with international agencies, IMD's cyclone track forecast accuracy is better than the leading nations including USA and Japan for all forecasts issued five days in advance
Appreciations		<p>(Appreciation from (i) Hon'ble Prime Minister for the accurate forecast of Hudhud (2014), (ii) According to the NCAER report(2015), 95% of the coastal population believe in cyclone warning and take action, (iii) Cyclone Warning Services of IMD earned a place among 100 Innovations that transformed India after independence: published in Indian Innovation by Dinesh C Sharma, (iv) (iii)Appreciation from WMO for forecasting cyclones (a)Phailin(2013), (b)Sagar and Mekunu (2018), (c)Titli and Luban(2018), (d)Amphan,2020 and (e)Mocha2023, (iv) King (then Prince) Charls visited IMD in 2019 and many other</p>

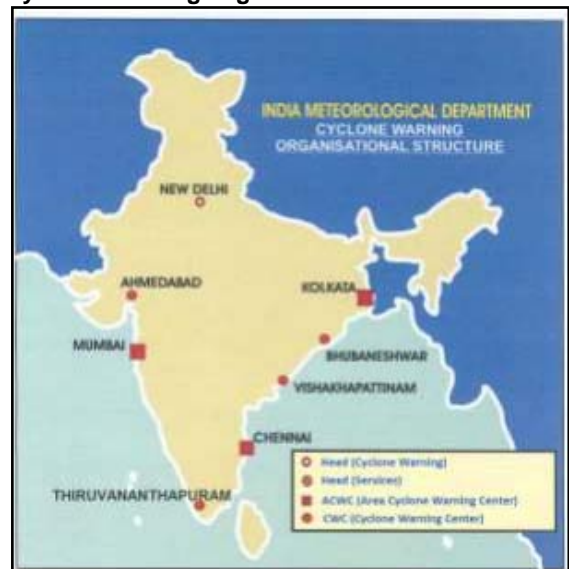
		<p>international dignitaries appreciated IMD's cyclone warning, (iv) UN DRR and WMO appreciated pin pointed forecast of cyclone Fani, (2019), (v) Appreciation from Hon'ble President of India for accurate forecast of FANI, (v) Leading TV channels including Discovery and Animal Planet, Washington Post, New York Times, Times of India, Indian Express, PTI, National and local TVs among many others appreciated cyclone warning and management in India</p>
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- Area Cyclone Warning Centre/Cyclone Warning Centre increased from 7 (2014) to 8 (2023) with the establishment of CWC Thiruvananthapuram in 2018 to cater to the maritime requirements of Lakshadweep, Kerala and Karnataka.
- At the National level, Cyclone Warning Division at Headquarters, New Delhi along with 3 Area Cyclone Warning Centres (ACWC) at Chennai, Mumbai, Kolkata and 4 Cyclone Warning Centres (CWC) at Bhubaneswar, Visakhapatnam, Thiruvananthapuram and Ahmedabad are responsible to cater to the cyclone warning services for the north Indian Ocean.

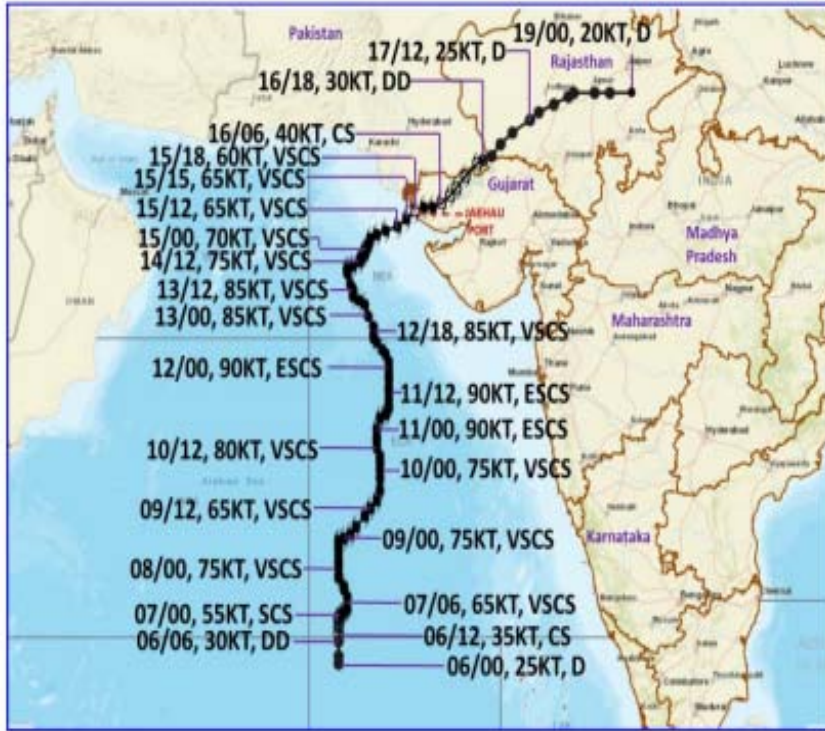
RSMC, New Delhi Domain



Cyclone Warning Organisational Structure of IMD

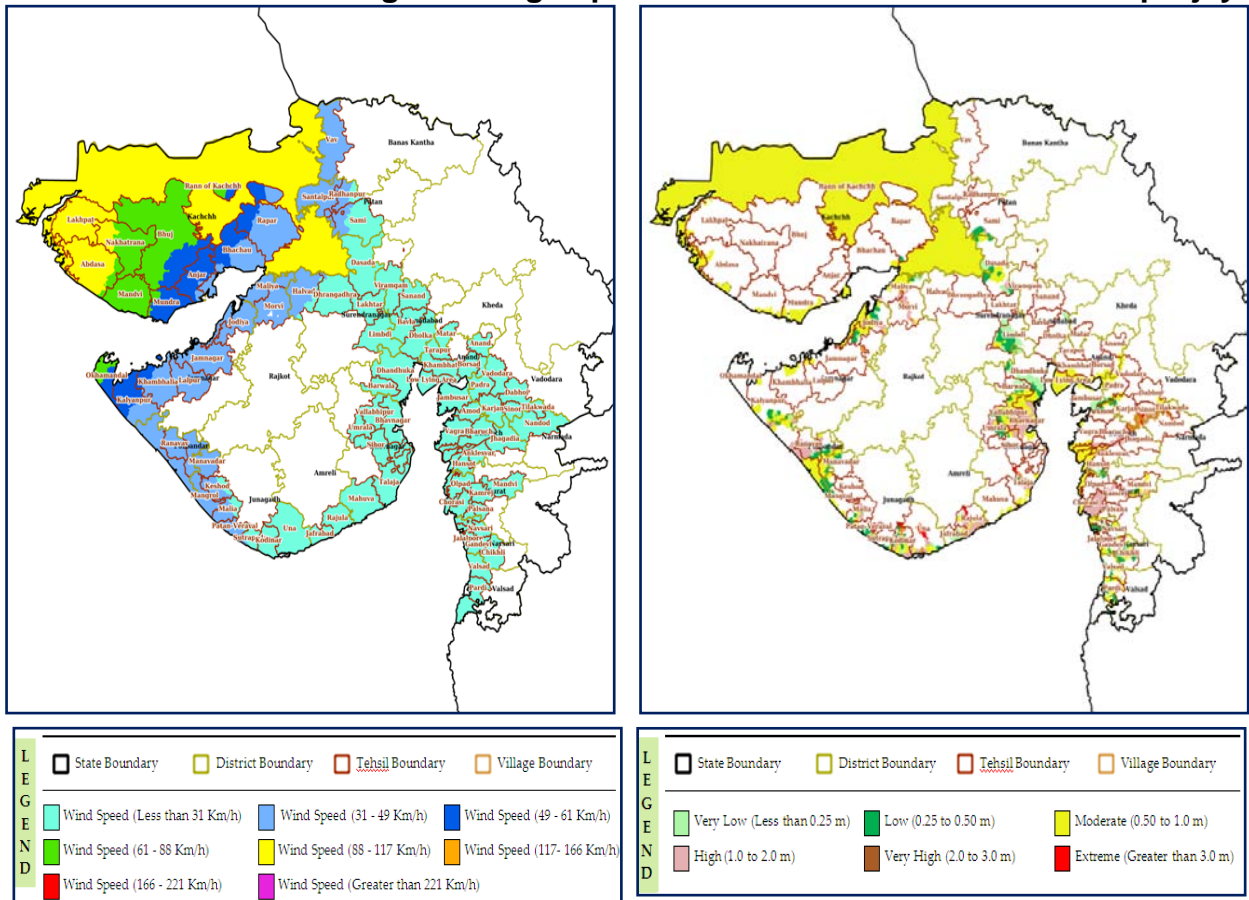


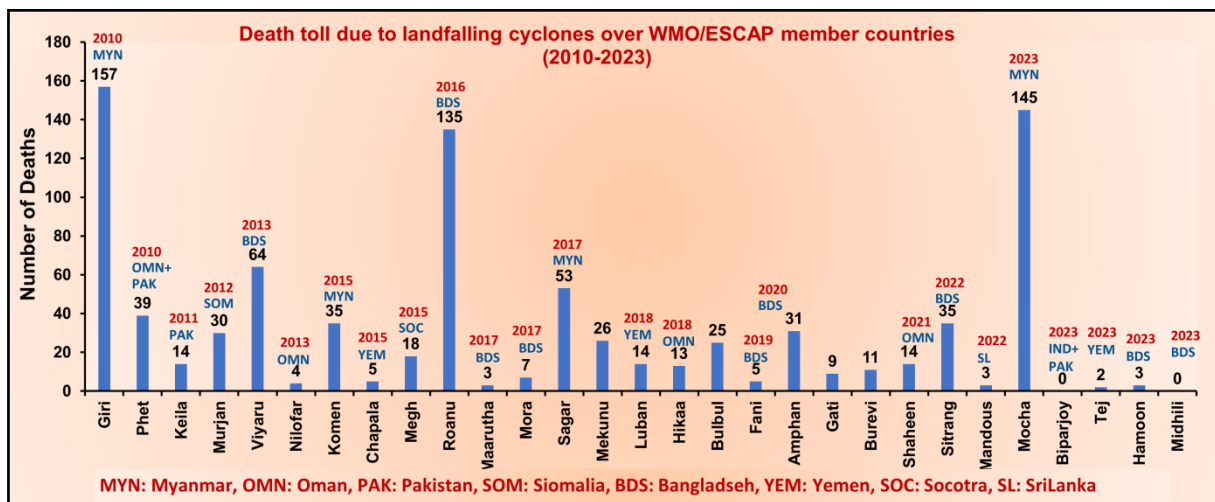
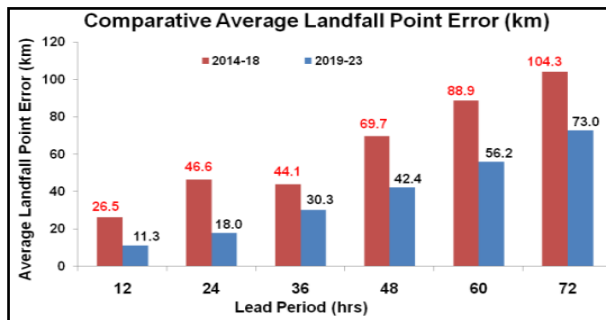
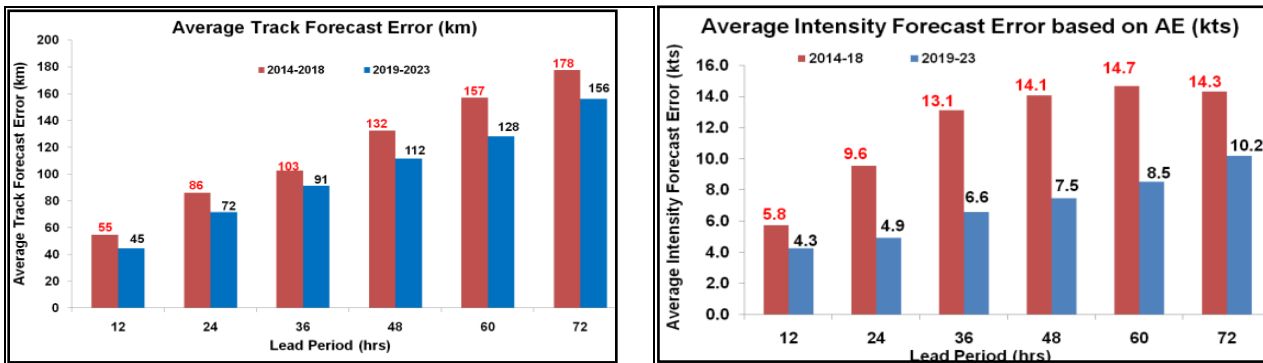
- A web-based Dynamic Composite Risk Atlas (Web-DCRA) and Decision Support System (DSS) tool for real-time Cyclone and associate impact-based forecasting in 13 coastal states (covering both eastern and western coasts) of the country was launched by National Disaster Management Authority (NDMA) on 28th of September, 2022. The Web-DCRA and DSS tools have been installed/hosted at the India Meteorological Department.



06-19 June 2023 (Extremely Severe Cyclonic Storm Biporjoy)

Web DCRA Tool used for generating impact based forecast at the time of Biporjoy





4.7 Marine Services

To safeguard human life at sea and marine assets, the India Meteorological Department has taken various initiatives in recent years as discussed below:

Initiatives for fishermen and offshore industries and ships in deep sea:

- (i) At the international level, Cyclone Warning Division & Marine Services Division at Headquarters, New Delhi provide (a) the advisories concerning cyclonic disturbances over the North Indian Ocean, (b) regular bulletins to the international shipping community in Met Area VIII(N) under Global Maritime Distress Safety System with respect to weather over sea.
- (ii) At National level, Cyclone Warning Division & Marine Services Division at Headquarters, New Delhi along with 3 Area Cyclone Warning Centres (ACWC) and 4

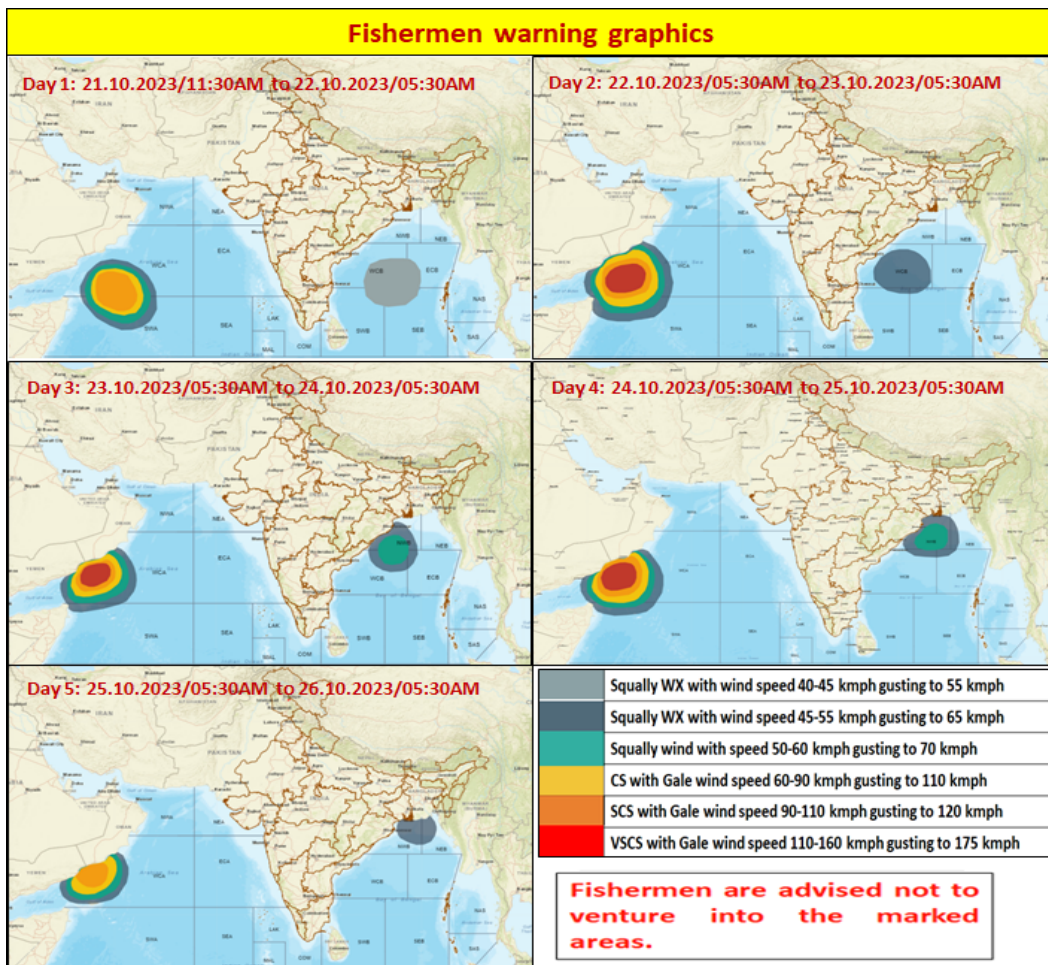
Cyclone Warning Centres (CWC) are responsible to cater to the maritime requirements.

- (iii) Under Global Maritime Distress and Safety System (**GMDSS**) Scheme, India has been designated as one of the 16 service providers in the world for issuing Sea area bulletins for vessels on high seas for broadcast through GMDSS for MET AREA VIII (N), which covers a large portion of NIO. As a routine, two GMDSS bulletins are issued at 0900 and 1800 UTC. During tropical cyclones/ depressions, additional bulletins (up to 4) are issued for GMDSS broadcast. In addition, coastal weather and warning bulletins are also issued for broadcast through NAVTEX transmitting stations. Fleet Forecasts for Indian seas are also issued for the Indian Navy twice a day with a validity period of twelve hours.
- (iv) Port warnings have been issued for all the 120 ports since 1865. IMD is in the process of developing a customised location-specific forecast for all the ports from 2024.
- (v) Increase in the lead period of cyclogenesis forecast from 3 days (2014) to 5 days (2018) and 7 days (2023) to increase the lead period of warnings and advisories in particular for the marine community, disaster managers and forecasters (already mentioned on page 1)
- (vi) Introduction of extended range outlook for cyclogenesis for the next two weeks in 2018 to increase the lead period of warnings and advisories in particular for the marine community, disaster managers and forecasters (already mentioned on page 1)
- (vii) Fishermen warnings for the entire North Indian Ocean in textual and graphical format since 2019 for the next 5 days based on a multi-model technique
- (viii) The graphical information about the probability of exceedance of winds exceeding 20 kts and 34 kts for the next 5 days for the entire north Indian Ocean since 2022.
- (ix) Dissemination of warnings to fishermen in the deep sea through the Navik system which is an indigenous GPS system developed by ISRO to inform the fishermen in deep sea about the natural disasters on their way.
- (x) Coastal area warnings (upto 40 nm off coast) and Sea area warnings (beyond 40 nm) in textual, graphical and GIS platforms since 2022
- (xi) Customised location-specific colour-coded warnings and forecast for the next 5 days for offshore operators since 2022
- (xii) Warnings for the extended area (Red Sea, Entire North Indian Ocean and upto 30⁰S and 120⁰E) for Naval Ships.
- (xiii) IMD is also in the process of providing customized forecasts for Indian Navy, Indian Coast Guard locations and ship routes
- (xiv) Regular posts on social media for fishermen warnings since 2023
- (xv) Regular awareness campaigns are organised by the coastal offices with the fishermen
- (xvi) IMD is working jointly with INCOIS to provide Met services to the oceanic region and integrating with the ocean state forecast of INCOIS for **Marine-Emergency Response (MER) for Marine Disaster Management.**

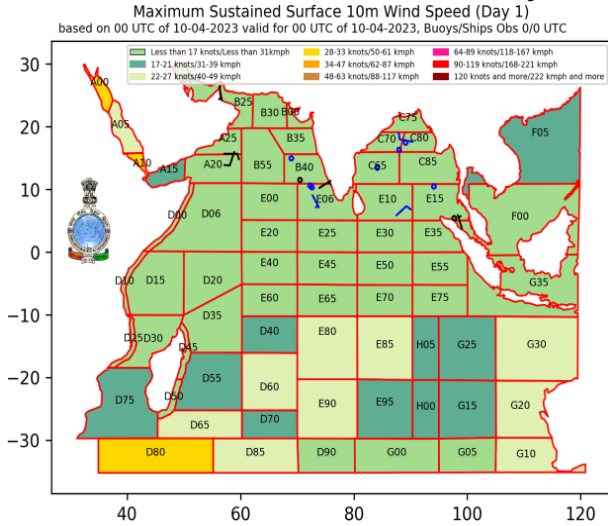
Bulletins for marine community by the India Meteorological Department

Marine Weather Forecasting and Warning Bulletins							
Bulletins	GMDSS Bulletin	Cyclone Warnings	Sea Area	Fleet Forecast	Coastal Weather	Fishermen Warnings	Offshore Industries
Frequency (Normal)	2 times/day	Once/day	2 times/day	2 times/day	2 times/day	2 times/day	Once/day
Frequency (Depression)	3 times/day	5 times/day	3 times/day	4 times/day	4 times/day	4 times/day	5 times/day
Frequency (Cyclone)	5 times/day	8 times/day	5 times/day	4 times/day	5 times/day	4 times/day	8 times/day
Format	Text	Text ,graphic, GIS	Text & graphic	Text	Text & graphic	Text & graphic	Text & graphic
Area	Global Area under sub divn VIII(N)	Entire North Indian Ocean for 13 countries	Deep sea beyond 40 nm off coast	As per IN requirement	Sea area within 40 nm off coast	Entire Bay of Bengal & Arabian Sea, North of Equator)	Offshore industries as per DGH
Dissemination	INMARSAT, Website	FAX, Email, website,SMS, Facebook, Tweet, whatsapp, video, Radio, Doordarshan	NAVTEX Websites	Email, IMD website	NAVTEX websites	Radio, Doordarshan, SMS, Websites, Mobileapp, email,FAX	Email, website, whatsapp
Information	Wind, weather, visibility, wave height	Synoptic system, track, intensity, landfall forecast, associated adverse weather, damage expected, action suggested	Synoptic system, wind, weather, visibility, wave height	Wind, weather, visibility, wave height	Synoptic system, wind, weather, visibility, wave height	Winds ≥45 kmpH Squally weather Rough sea Swells	Customised forecast of nearest distance, intensity & time of arrival

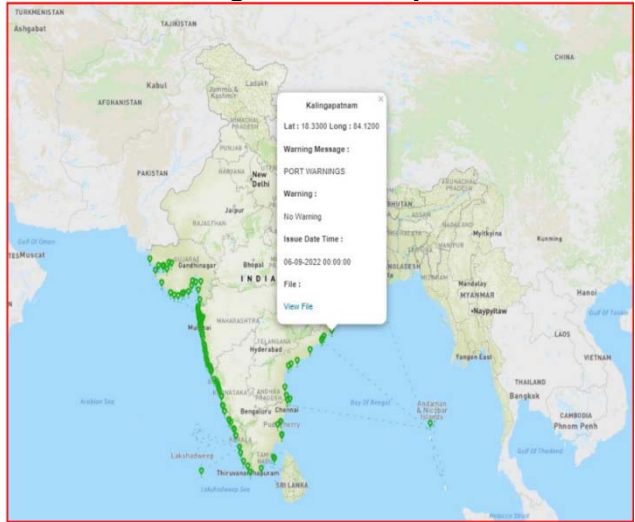
Fishermen Warning Graphics for the entire NIO valid for the next 5 days based on multi-model ensemble



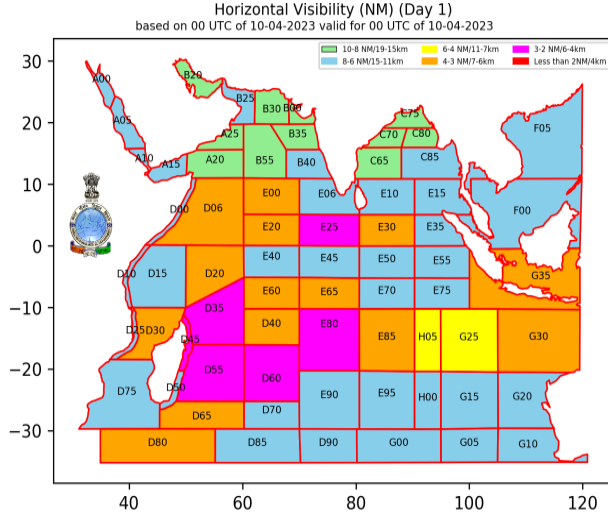
10m wind forecast for Indian Navy



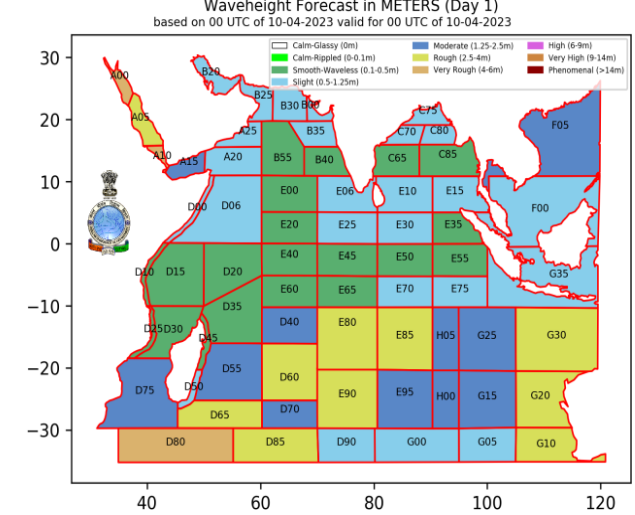
Port Warnings for Indian ports



Horizontal visibility forecast for Indian Navy



Wave height forecast for Indian Navy



Customised bulletins for Offshore/onshore industries

TABLE 4: CYCLONIC DISTURBANCE FORECAST FOR BAY OF BENGAL & MAJOR AREAS OF E&P OPERATIONS, BASED ON 1130 hrs IST of 8th December, 2022

SI	DESCRIPTION Name (Lat° N/ Long° E)	LOCATION		CURRENT LOCATION FROM CENTRE OF CYCLONIC DISTURBANCE		FORECAST PARAMETERS WHEN THE INSTALLATION WOULD BE NEAREST TO THE CYCLONE PATH							
		LAT (°N)	LONG (°E)	DIST ANCE (NM)	DIREC TION	DATE/ TIME (IST) OF OCCURRENCE	DIS TAN CE OF RIG FROM PAT H	DIREC TI ON OF RIG FROM PAT H	UNCER TAINIT Y IN DISTA NCE OVER PATH (NM)	MSW OVER RIG(KTS)	UNCER TAINIT Y IN MSW OVER RIG (KT)	SIGNIFIC ANT WAVE HEIGHT	STATE OF SEA
BAY OF BENGAL AREA													
1.	South West Bay of Bengal (SWB) (13.25/81.50)	9.7	83.5	244	NNW	09.12.22/2030	89	NE	52.5	33	5	4 - 6	Very Rough
2.	West Central Bay of Bengal (WCB) (15.00/83.00)	9.7	83.5	320	N	09.12.22/2030	225	NE	52.5	<27	5	<4	Rough
3.	East Central Bay of Bengal (ECB) (14.25/92.00)	9.7	83.5	570	ENE	08.12.22/1130	570	ENE	10	<27	5	<4	Rough
4.	North West Bay of Bengal (NWB)-1 (18.50°)	9.7	83.5	542	NNE	09.12.22/2330	479	NE	55	<27	5	<4	Rough

Color Code for generating impact based forecast:

ZONE	PARAMETERS
GREEN	NORMAL SITUATION, NO FORECAST OF CYCLONE
YELLOW	(1) A TROPICAL CYCLONE FORECAST: THE STORM CENTRE WITHIN 800 NM FROM LOCATION AND (2) THE FORECAST TRACK IS FORECAST TO BE WITHIN 300 NM FROM LOCATION
ORANGE	(1) A TROPICAL CYCLONE FORECAST: THE STORM CENTRE WITHIN 600 NM FROM LOCATION AND (2) THE FORECAST TRACK IS FORECAST TO BE WITHIN 200 NM FROM LOCATION AND (3) SUSTAINED WIND SPEED ALONG THE PATH IS FORECAST TO EXCEED 50 KTS
RED	(1) A TROPICAL CYCLONE FORECAST: THE STORM CENTRE WITHIN 300 NM FROM LOCATION AND (2) THE FORECAST TRACK IS FORECAST TO BE WITHIN 150 NM FROM LOCATION AND (3) SUSTAINED WIND SPEED ALONG THE PATH IS FORECAST TO EXCEED 65 KTS

Notes:

(1) Under each zone, all three parameters are to be fulfilled to declare the rig under that zone

(2) The distance from Forecast Track in S1 No.2 of each zone is the minimum distance of the rig from the track/path when it is passing through i.e. when it is closest to the rig

4.8 Severe Weather Forecasting Programme of WMO

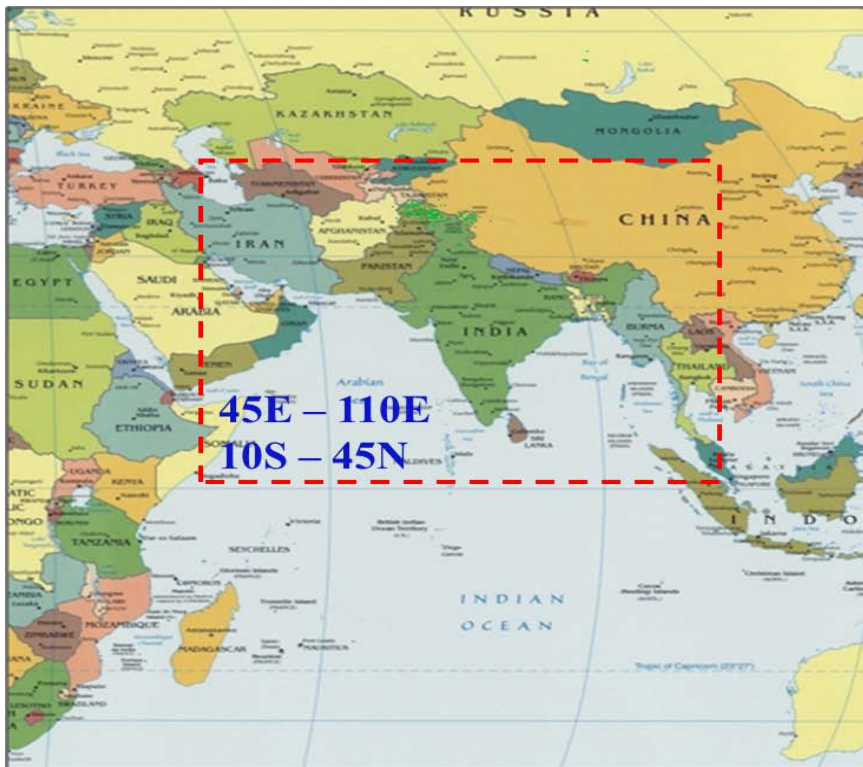
- SWFP is a three-way cascading process with Global Modeling Centres, Regional Centres and National Meteorological & Hydrological Services (NMHSs) as partners with an objective to enable the NMHSs to have greater capability to identify hazardous weather conditions in the short- and medium-range and issue forecasts and warnings accordingly.
- IMD leads WMO's SWFP-South Asia to predict severe weather viz, heavy rain, strong winds, high waves, cyclonic disturbances and storm surge for 9 member countries including Bangladesh, Bhutan, India, Maldives, Myanmar, Nepal, Pakistan, Sri Lanka, and Thailand since May, 2016 in graphical format for next 5 days.
- 2019 marked the introduction of textual products with the inclusion of guidance in short medium range, risk tables in short range and probability tables in medium range.
- 2023 marked the introduction of impact-based forecast and risk-based warnings in GIS and QGIS for heavy rainfall, strong winds, significant wave height, cyclonic disturbance and storm surge for the area of responsibility.

2011-2014: Assessment, planning, drafting (Regional Subproject Implementation Plan) RSIP, workshops and final review of RSIP through SWFDP-Bay of Bengal

2015: Launch of RSMC New Delhi web portal for SWFP; Joint Training Workshop for both the Bay of Bengal (South Asia) and Southeast Asia sub-regions.

Regional Guidance Products by RSMC New Delhi

- Short Range (1-2 days) and Medium Range (3-5 days) guidance products for next 5 days:
- Graphical WX forecast products
- Risk Guidance for precipitation & winds (graphical, tabular, GIS) for all 95 subdivisions based on MME guidance from 5 global models (New)
- Discussion of main synoptic features, satellite features and forecast of heavy rainfall & strong winds and Flash Flood Guidance



Members (9)

- Thailand
- Myanmar
- Bangladesh
- India
- Bhutan
- Nepal
- Sri Lanka
- Maldives
- Pakistan

Domain of SWFP-South Asia

SEVERE WEATHER FORECASTING PROGRAMME (SWFP)-SOUTH ASIA
REGIONAL SPECIALISED METEOROLOGICAL CENTRE, NEW DELHI

Guidance Prod.
Interactive Guidance

Day-1 -->> Weather Guidance

Day-2 -->>

Day-3 -->>

Day-4 -->>

Day-5 -->>

Discussion

View all (Day-1 to Day-5)

SAFG -->

Evaluation Form

Guidance Prod. Archive -->

DAY - 1: 15.09.2023/0600 UTC to 16.09.2023/0600 UTC

24 Hrs. Rainfall

- ≥ 50mm
- ≥ 100mm

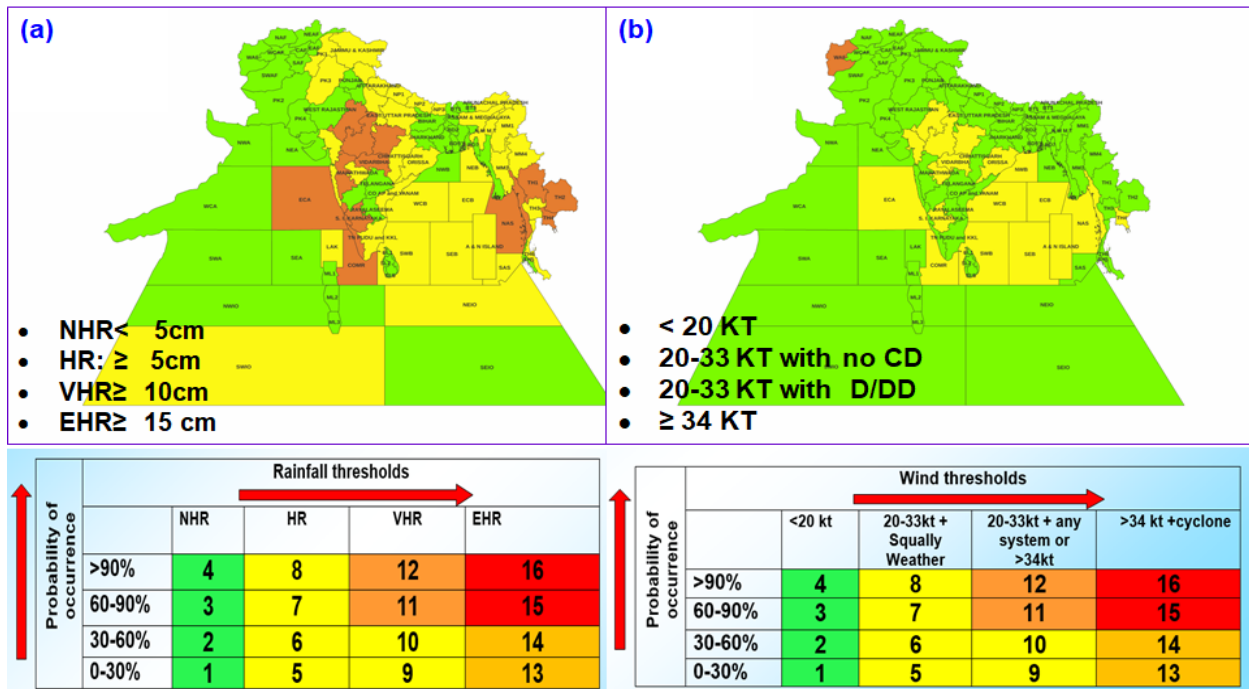
Squally weather

- 17-27 KT(32-51 KMPH)
- 28-33KT(52-61 KMPH)

Gale wind

- 34-49KT(62-91 KMPH)
- 50-63KT(92-117 KMPH)
- ≥ 64 KT(≥ 118 KMPH)
- High Waves ≥ 2.5 m
- Storm Surge ≥ 1 m

Severe Weather Guidance Portal on RSMC website
Risk Guidance for (a) heavy rainfall and (b) strong winds for Next 5 days
(98 sub-divisions)



4.9 Heatwave forecast and warning services

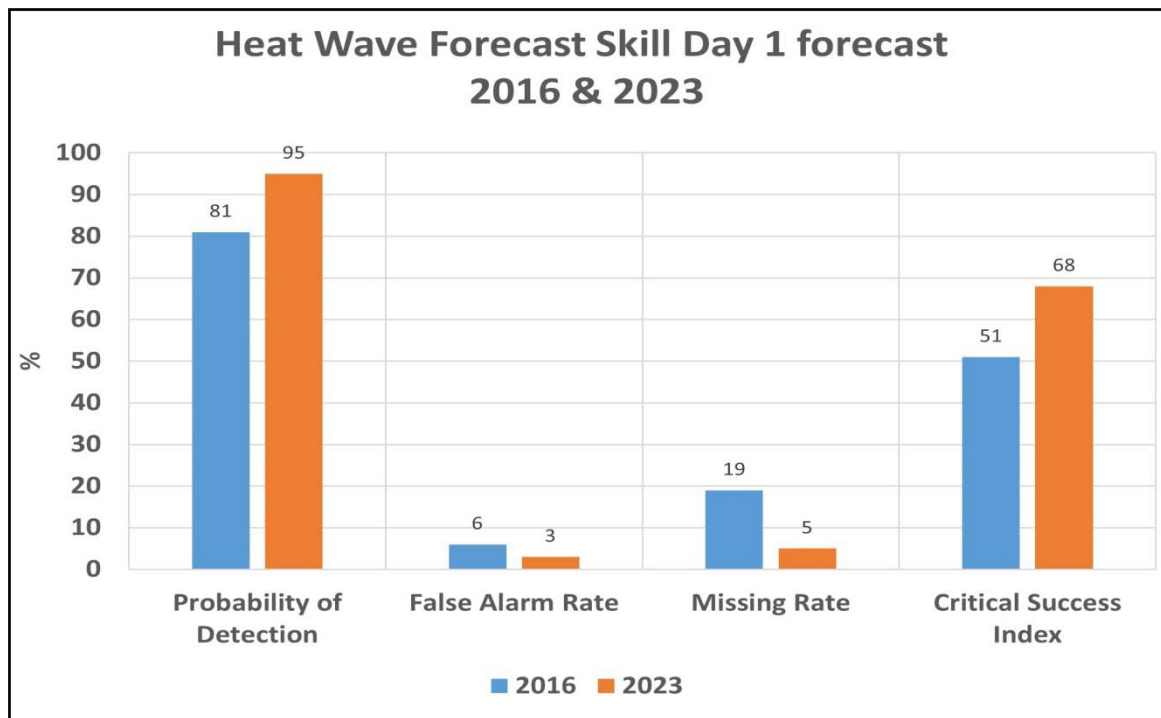
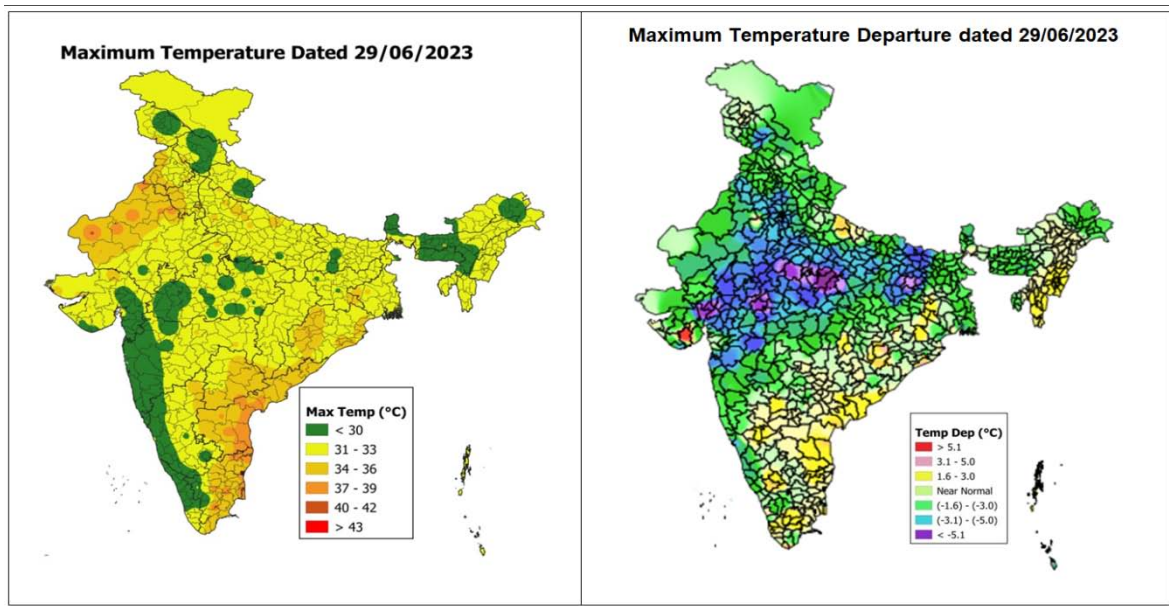
- IMD in collaboration with local health departments has started a heat action plan in many parts of the country to forewarn about the heatwaves and also advising action to be taken during such occasions. The heat action plan became operational in 2013.
- The Heat Action Plan is a comprehensive early warning system and preparedness plan for extreme heat events. The Plan presents immediate as well as longer-term actions to increase preparedness, information-sharing, and response coordination to reduce the health impacts of extreme heat on vulnerable populations. NDMA and IMD are working with 23 states prone to high temperatures leading to heat-wave conditions for supporting heat action plans.
- Considering data for the years 2016 to 2023, there has been a gradual improvement in the heat wave forecasting skill as seen from different skill scores. The Probability of Detection has improved by 20%-30% for Day 1 to Day 5 forecasts in 2023 as compared to 2016 and the POD for Day 1 forecast reached 95% in 2023 against 81% in 2016.
- After the death of about 2,000 people due to heatwaves in 2015, several actions have been taken by MoES/IMD. To minimize the loss of life due to heatwaves, during the summer session for the period from 1 April to 30 June, IMD issues colour-coded impact-based heatwave warnings for the benefit of the public and users since 2019 at the district level. The criteria for the colour code used for the purpose are given in the table;

Green (No action)	Normal Day	Maximum temperatures are near normal
Yellow Alert (Be updated)	Heat Alert	Heat wave conditions at isolated pockets persists on 2 days
Orange Alert (Be prepared)	Severe Heat Alert for the day	(i) Severe heat wave conditions persists for 2 days (ii) Through not severe, but heat wave persists for 4 days or more
Red Alert (Take Action)	Extreme Heat Alert for the day	(i) Severe heat wave persists for more than 2 days. (ii) Total number of heat/severe heat wave days exceeding 6 days.

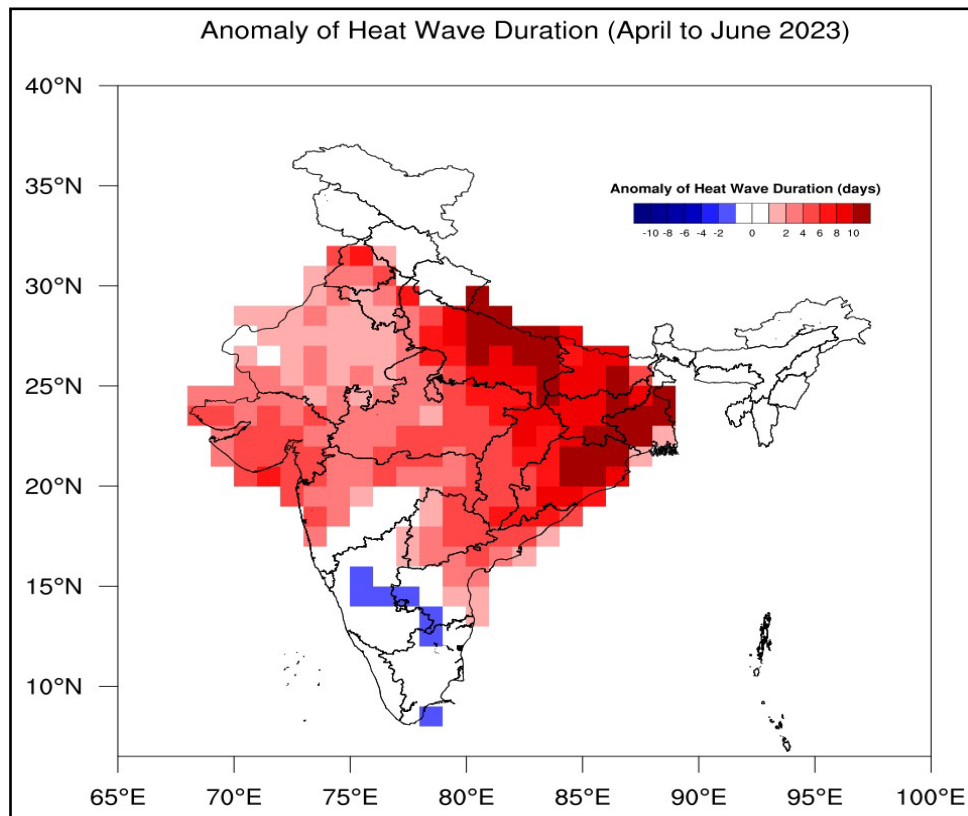
- IMD also issues the impacts and suggested actions concerning the intensity of heat waves and the colour code used for related warnings, in collaboration with NDMA. Details of the same are given in the table below;
- The seasonal and monthly forecast of maximum temperature, minimum temperature and heat wave conditions have been provided during the summer season since 2016.
- Extended range forecast bulletin (including temperature forecast and warnings for the next two weeks) has been issued every Thursday since 2017
- Many new Information in Web-GIS has been added for better interpretation of Heat Wave warnings by various users since 2020 like
 - a) Interactive Map for actual Maximum temperature & its Departure from normal temperature based on the situations of the day.
 - b) Interactive Map for Heatwave and Severe Heatwave along with Warm Nights and very Warm Nights based on the situations of the day.

	Status in 2014	Status as on 2023
Heat Wave Action Plan	Nil	Commenced by NDMA and SDMA's in 2015 in collaboration with IMD and others
Accuracy	12 hours ahead: 67% 48 hours ahead: 50% 72 hours ahead: 27%	12 hours ahead: 100% 48 hours ahead: 95% 72 hours ahead: 90% Quantum jump in accuracy for all lead periods.
No. Of deaths	2000 in 2015	Double Digit by 2023

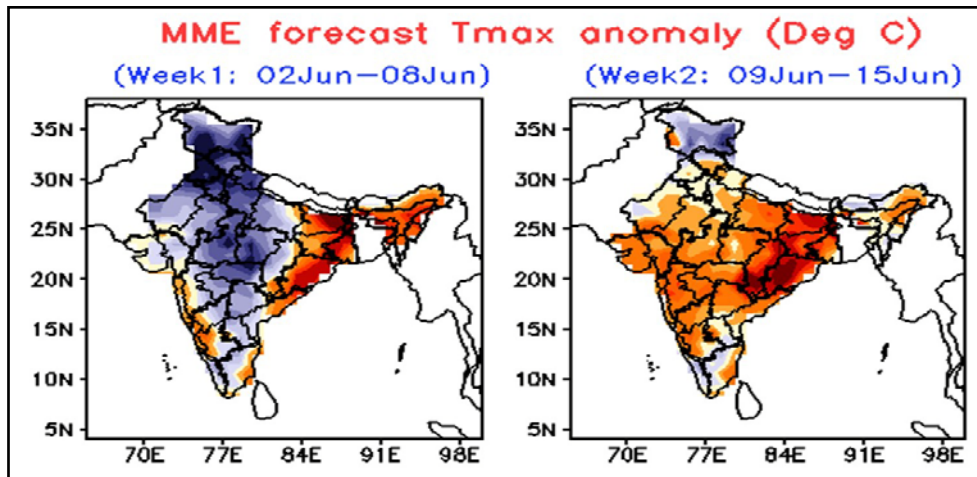
Web-GIS based plot of maximum temperature and its departure



Seasonal forecast of Heatwave duration anomaly issued on 1st April 2023



Extended range forecast of maximum temperature anomaly for 2 weeks based on 30 May 2023 and valid for the period from 02-15 June 2023.



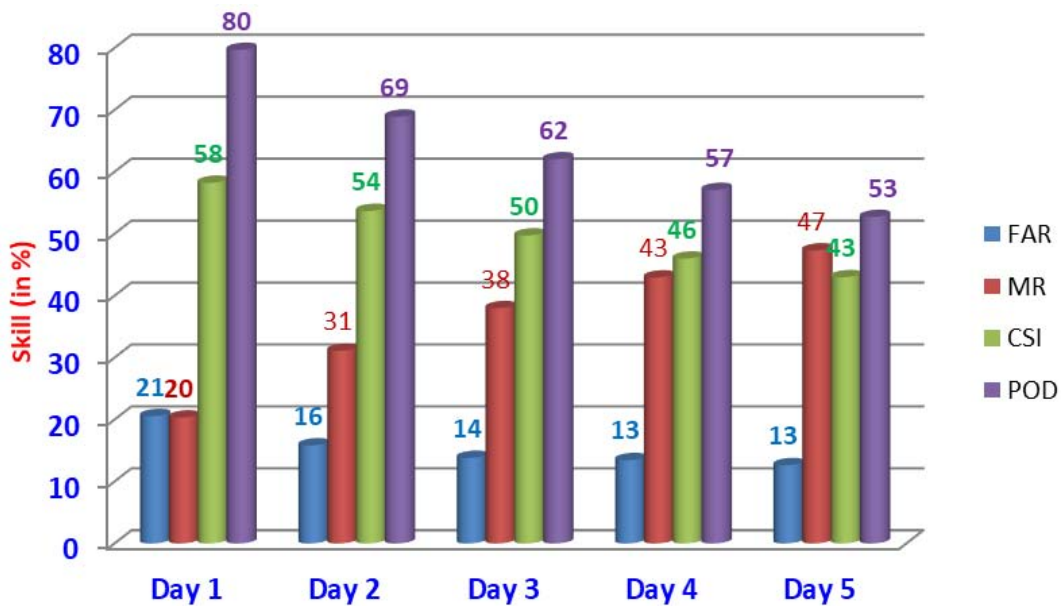
4.10 Heavy Rainfall Forecast and Warning Services

IMD issues various outlooks/forecasts/warnings for the Public as well as Disaster Management Authorities for the preparedness of extreme weather events and adaptation of various climate-related risks. IMD utilizes all its observational and forecasting systems to issue impact-based heavy rainfall warnings to state and central agencies and other stakeholders. These forecasts and warnings are issued through the National Weather Forecasting Centre, New Delhi and State Meteorological Centres for the concerned state.

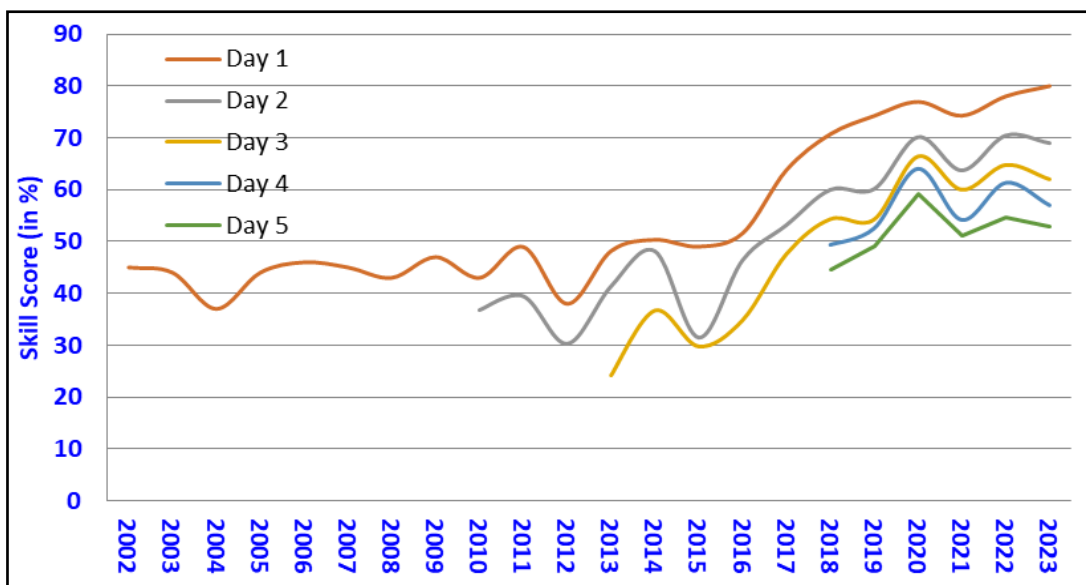
IMD issues short to medium-range forecasts and warnings daily valid for the next five days with an outlook for the subsequent two days. The short to medium-range forecast and warning at district and station levels are issued by state-level Meteorological Centres (MCs)/Regional Meteorological Centres (RMCs) with a validity of the next five days and are updated twice a day.

Category	2014	2023
Heavy Rainfall Warnings		
Stages of Warning	Single stage	4 stage heavy warning <ul style="list-style-type: none"> ➤ Heavy Rainfall Watch (72 hours prior to occurrence), ➤ Heavy Rainfall Alert (48 hours prior to occurrence), ➤ Heavy Rainfall Warning (48 hours prior to occurrence) and ➤ Nowcast (3-6 prior to occurrence)
Lead Period of forecast	5 days	7 days
District-wise warnings	No	For all 739 districts
Forecast Accuracy	24 hours ahead: 50% 48 hours ahead: 48% 72 hours ahead: 37%	24 hours ahead: 80% 48 hours ahead: 70% 72 hours ahead: 65% 96 hours ahead: 57 % 120 hours ahead: 53 % By that way the disaster managers and public have got a lead period of 5 days with accuracy of > 50% for heavy rainfall management.

The probability of Detection of heavy rainfall is between 80% to 53% from Day 1 to Day 5. False Alarm Rate (FAR) is between 21% to 13% from Day 1 to Day 5.



Verification scores of heavy rainfall forecast at meteorological sub-division level during monsoon season 2023. FAR : False Alarm Ratio; MR: Missing Rate; CSI : Critical Success Index; POD : Probability of Detection



Probability of Detection (POD) of Heavy rainfall at meteorological sub-division level from 2002 to 2023

- By 2023, Probability of Detection (POD) for southwest monsoon heavy rainfall warning is 80 for day 1, 69 for day 2 and 62 for day 3 as compared to 50 for day 1, 48 for day 2 and 37 for day3 in 2014.
- Day 5 skill in 2023 (53%) is better than Day 1 skill in 2016 (52%) and all proceeding years. Hence, there is an improvement in the lead period of the forecast by 4 days.

4.11 Urban Flood Forecasting

Urban Floods over India are mainly associated with shorter-duration heavy rainfall events. It occurs normally during active monsoon periods, triggered by major monsoonal systems when moved over a city or part of it or it may be triggered by localized thunderstorms which are convective systems.

For the implantation of appropriate Urban heavy rainfall and associated Flash flood Early warning systems, multi-intuitional efforts have been initiated by MoEs in collaboration with IITs, IISC, C-DAC, ISRO etc, and major City Municipality Corporations, concerned city disaster authorities including concerned state Govt.

In recent periods of 2019-2023, Urban rainfall monitoring networks improved significantly over major cities like Mumbai, Chennai, Delhi, Bhubaneswar, Bengaluru, Guwahati, Pune, Kolkata, Ahmedabad and additional RADARS have been installed. Meso-scale Nowcast models also are being run. Exposures and vulnerability were computed. Risk analyses are also carried out using past rain and impact data for all these major cities. Impact-based ward-wise end-to-end Dynamic NWP-based urban flood warning systems have been operational since monsoon 2020 for two major cities of Mumbai and Chennai which have been most vulnerable. These 2 new systems are Integrated Flood Warning System for Mumbai referred to as **I-FLOWS** and Chennai Flood Warning System or **C-FLOWS**. The system can estimate floods up to 3 days in advance. The system also provides 3 hours – 6 hours nowcast (forecast up to 3 hours) and in low-lying areas forecasts up to 12 hours in advance.

Development and implementation of similar systems are in progress for other major cities of India (Delhi, Bengaluru, Bhubaneswar, Guwahati, Pune, Kolkata, Ahmedabad). These are integrated end to end system (with DSS) and it provides color coded Graphical map form and text based, actionable warnings along with likely Impacts at Ward-wise.

IMD has also implemented four-stage Impact Based early warning System using their products, to effectively help disaster mangers and other stake holders, to manage all urban Heavy Rainfall events and associated urban floods for all Major Cities of India from monsoon 2022.

Stage -1: Heavy rainfall Advisory (Watch)-(3-4 days lead time with 12-h updates,

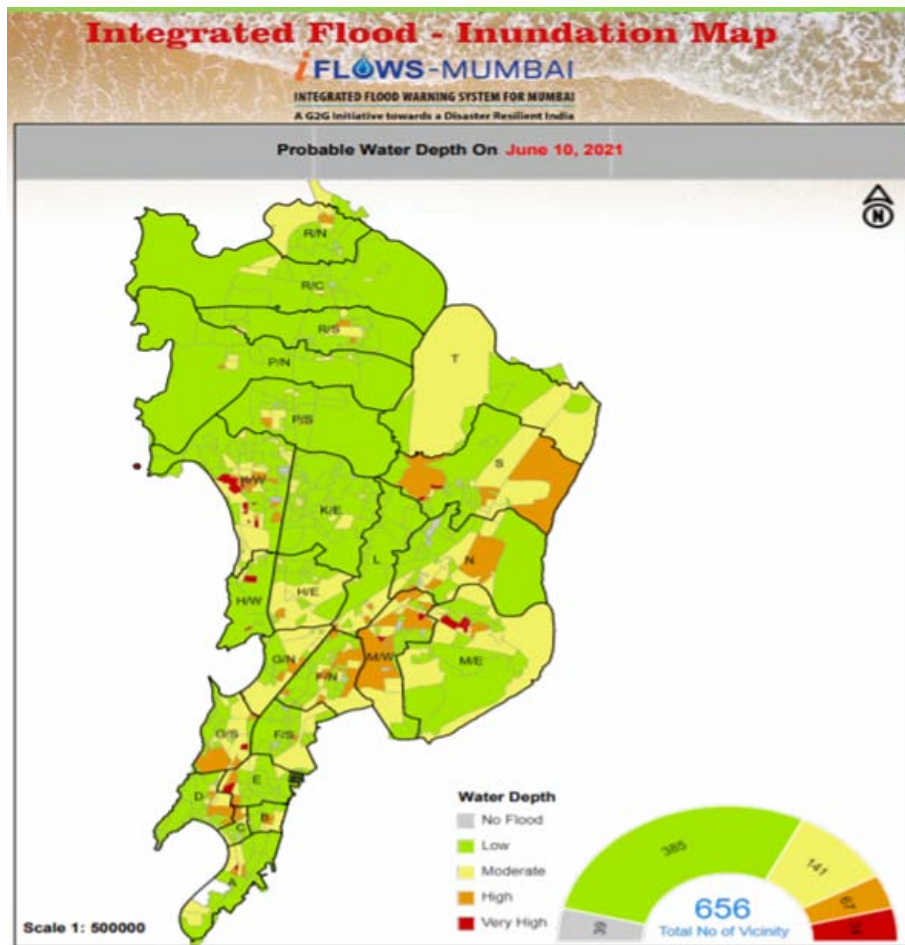
Stage-2: Heavy rainfall Alert (48 hours prior to the occurrence of the event at 12 hourly updates,

Stage-3: Heavy rainfall Warning and IBF from likely flash floods (24 hours prior to the occurrence of the event at 06/12-hourly updates,

Stage-4: 12 hours prior to occurrences of maximum rainfall spell and color-coded IBF from likely flash floods).

All this information and warnings are delivered, at the Disaster Managers Desk for timely decision in real-time, with a lead time of 3-12 hours, with guidance at 3-5 days lead period, for taking early actions e.g. action to divert the traffic/closed the flooded roads, and all other safety actions well in advance before the flood hits an area. It uses all the latest digital dissemination systems like CAP, API, WhatsApp, etc for timely dissemination to users.

By 2023, Urban Flood Forecast – IFLAWS established for the cities of Mumbai, Chennai and Kolkata, it was not available in 2014.



C-FLOWS - An Integrated WebGIS based Decision Support System to aid the Tamil Nadu Government in Flood Mitigation and Relief Operations

C-FLOWS
 CHENNAI FLOOD
 WARNING SYSTEMS

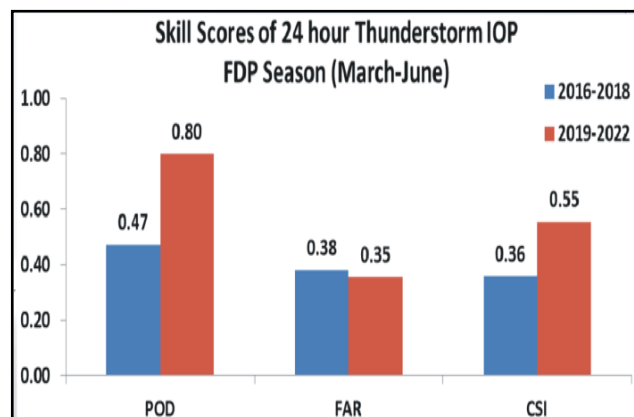
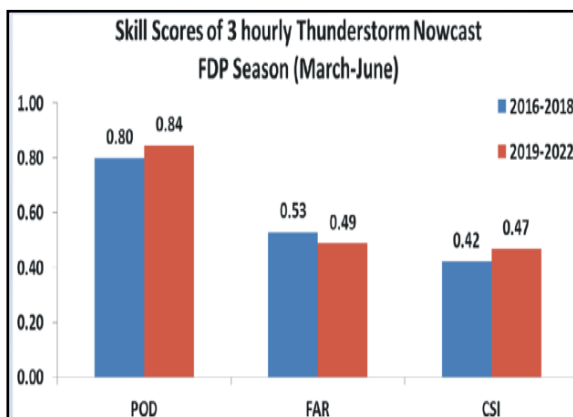
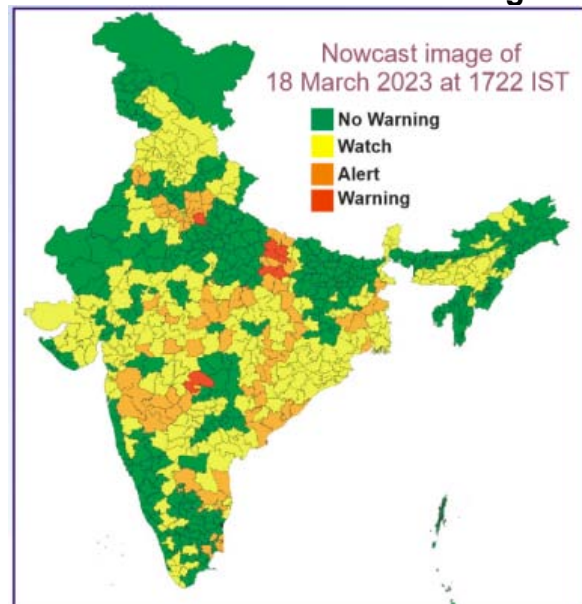
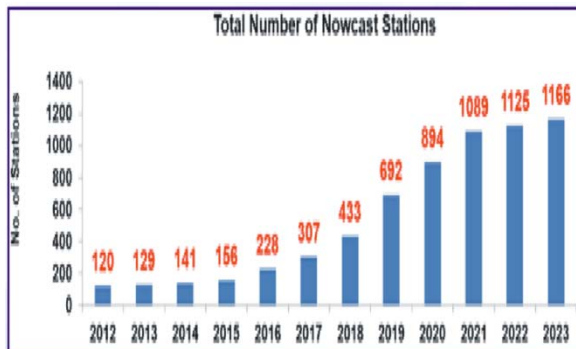
Color	Flood Depth (Feet)
White	< 1ft
Blue	1-2ft
Green	2-3ft
Yellow	3-4ft
Orange	4-5ft
Red	5-6ft
Dark Red	> 6ft

FLOOD VULNERABILITY

4.12 Thunderstorm and Lightning Forecasts & Warning

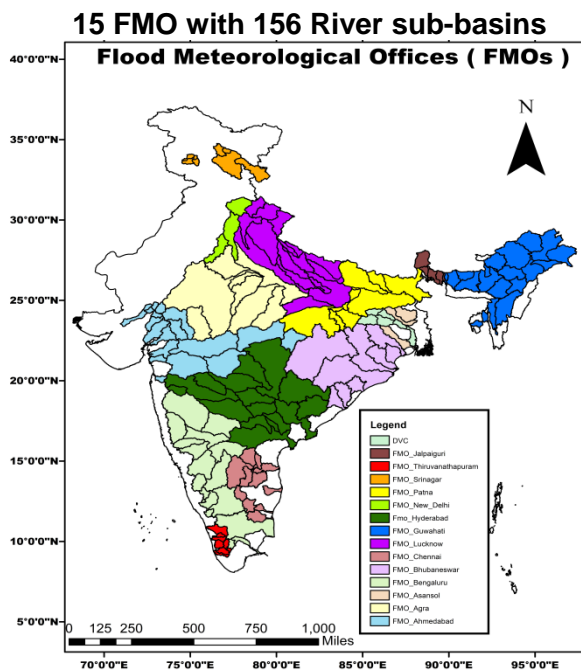
- Issued 5 days in advance presently as compared to 3 days in advance during 2014.
- Used to be issued at the Subdivision level only in 2014. By 2023, it is issued at Sub division level, district level, and station level and updated twice a day.
- Accuracy in thunderstorm nowcast has improved significantly during the recent years.
- The probability of detection for hourly thunderstorm Nowcast is 0.86 as compared to 0.50 in the year 2017.
- Three Hourly Thunderstorm Warning at 732 district level
- Nowcast of severe weather events increased from 120 to 1166 stations in 2023.
- District-level Nowcasting started in 2018.
- Lightning warning system in the country started since 2019.
- India is among the 5 countries to have a Lightning warning system.
- Multi-hazard forecast and nowcast warnings are being issued districtwise and stationwise at IMD website.
- Nowcast warnings are updated every 3 hours.

Districtwise Nowcast Warning

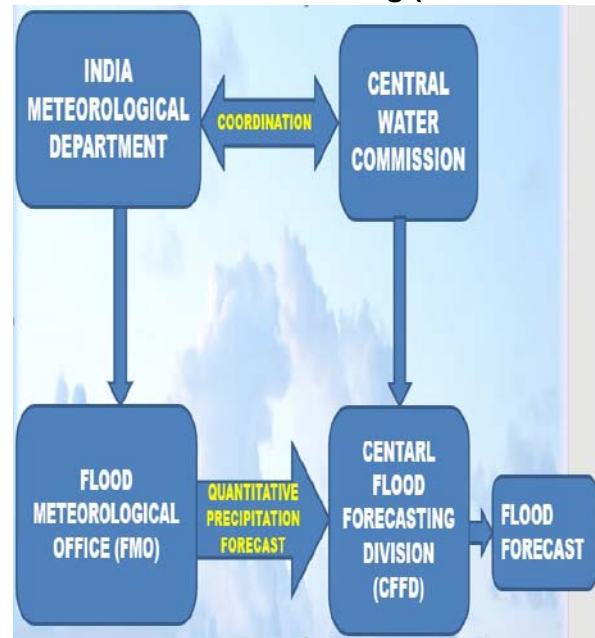


4.13 Hydromet Services & Quantitative Precipitation Forecast (QPF)

- Commissioned New Flood Meteorological Offices at Srinagar, Bengaluru, Chennai and Thiruvananthapuram which, increased the total nos of 15 FMOs.
- The validity of QPF was for 2 days and the outlook for the subsequent 3 days in 2014.
- Presently, Validity is for the next 5 days with the outlook for the subsequent two days.
- More than 10% improvement in the accuracy of QPF recorded since 2016.
- Increased the river sub-basins by 35 nos. from 121 to 156 for issuing of QPF in recent years
- Initiated the issuance of probabilistic QPF.
- Utilization of high-resolution dynamical Models for decision-making in issuing QPF.
- Initiated the Joint advisories by IMD, CWC and NDRF on the Flood Status of the country.





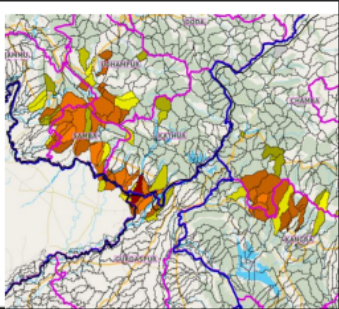
Riverine Flood Forecasting (Quantitative



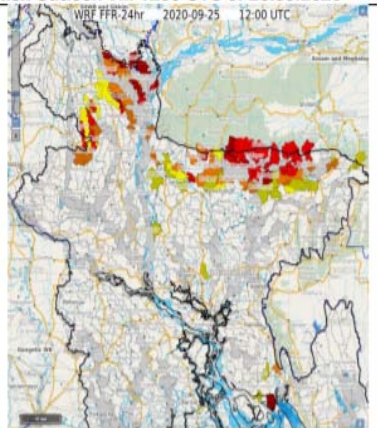
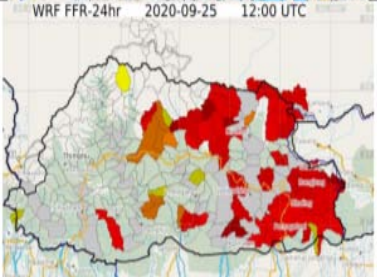


South Asia Flash Flood Guidance System (SAsiaFFGS)

- ❖ IMD in collaboration with WMO jointly implemented the **South Asia Flash Flood Guidance System (SAsiaFFGS)** project and provides flash flood advisories in the form of threat and risk operationally to National Meteorological & Hydrological Centres in Nepal, Bhutan, Bangladesh, Sri Lanka & India since October 2020. IMD is the Regional Centre for South Asia.
- ❖ Presently High Resolution (4x4 km) Flash Flood Guidance system provides flash flood guidance for >30,000 watersheds in India and the South Asian countries of Nepal, Bhutan, Bangladesh and Sri Lanka daily. It was not available in 2014.
- ❖ IMD provides location-specific Flash Flood guidance advisory up to watershed level (1 lakh watersheds) four times a day.
- ❖ Capable of issuing flash flood Threat and risk for next 6 and 24 hours respectively.

National Flash Flood Guidance Bulletins

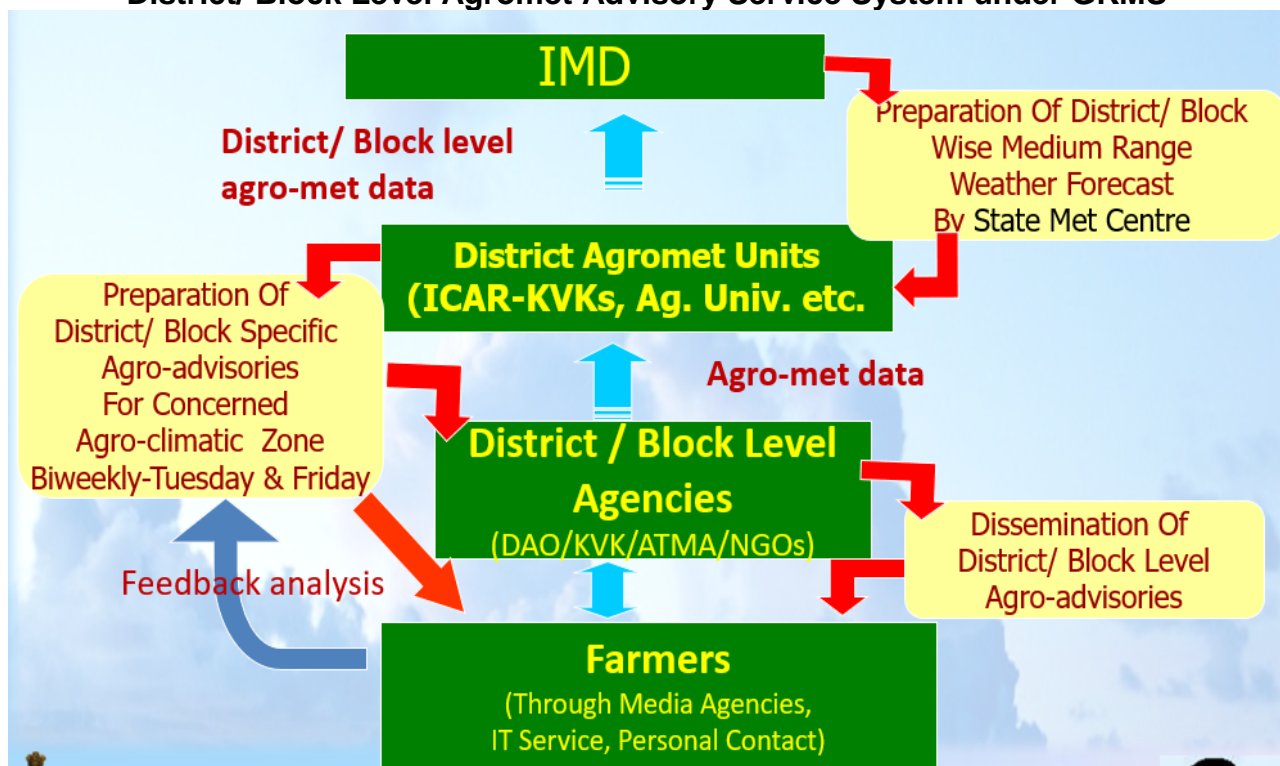
	GOVERNMENT OF INDIA MINISTRY OF EARTH SCIENCES INDIA METEOROLOGICAL DEPARTMENT HYDROMET DIVISION FLASH FLOOD GUIDANCE CELL	
National Flash Flood Guidance Bulletin		
DATED: 23.07.2022 TIME OF ISSUE: 1300IST VALID TILL 1730 IST From: India Meteorological Department, New Delhi (Email Id: sasiaffg.imd@gmail.com)		
To: RMC New Delhi, RMC Chennai, RMC Nagpur, MC Dehradun, MC Shimla, MC Srinagar, MC Hyderabad, MC Amrawati, MC Nagpur and concerned FMO's.		
Area of Concern (AoC): Few Watersheds & neighborhoods of western parts of Jammu & Kashmir, Uttarakhand, Himachal Pradesh, Telangana, adjoining Marathwada & adjoining Vidarbha Met subdivisions.		
Diagnostic Guidance: Based on Merged Mean Areal Precipitation at 1130 IST, recorded rainfall is up to 105 mm in last 6 hours and up to 240 mm in last 24 hours over few watersheds and neighborhood of Telangana, Jammu & Kashmir & Ladakh, Uttarakhand, and Kerala & Mahe met subdivisions. Land Surface Model shows few fully 100% saturated watersheds & few nearly saturated watersheds up to 85% over Telangana, Jammu & Kashmir & Ladakh, Uttarakhand, Himachal Pradesh and Kerala & Mahe met subdivisions and up to 55% soil saturation over remaining parts of the country.		
Prognostic Guidance: Dynamic Global (GFS) & Mesoscale Model (WRF & NCUM) forecasts Moderate rainfall up to 150 mm in next 24 hours.		
Observed Flash Flood Threat (OFFT) till 1130 IST of 23.07.2022: Moderate to High Flash flood threat over Samba, Udhampur, Jammu, Reasi & Kathua districts of Jammu & Kashmir and Chamba & Kangra districts of Himachal Pradesh Met Sub-division observed in last 06 hours.		
Disclaimer: This is only a guidance bulletin and not a warning for flash floods.		

	GOVERNMENT OF INDIA MINISTRY OF EARTH SCIENCES INDIA METEOROLOGICAL DEPARTMENT HYDROMET DIVISION FLASH FLOOD GUIDANCE CELL	
24 hour Flash Flood Risk Outlook Till 1200 UTC of 26.09.2020		
For Bangladesh: Low to Moderate Flash Flood Risk over some watersheds of North Bangladesh & neighbourhoods in next 24 hours.		
For Bhutan: Low to Moderate Flash Flood Risk over some watersheds of North & Eastern parts of Bhutan & neighbourhoods in next 24 hours.		

4.14 Agromet Advisory Services

- Gramin Krishi Mausam Sewa (GKMS) is functional for 329 districts by 2013 as compared to 130 districts in 2014.
- Weather forecast is issued for 6818 blocks and 721 districts by 2023 as compared to 608 districts in 2014.
- Agrometeorological advisory services are operational for 721 districts and 3100 Blocks in 2023 as compared to 608 districts in 2014. There were no block-level weather forecasts and agromet advisory service started in 2018 and covered the entire country in 2022.
- Dissemination of weather forecast and agromet advisory through village-level WhatsApp group started in 2020-2022.
- Impact Based severe weather forecast for agriculture started in 2020
- By 2023, 199 District Agro-Met Units (DAMUs) have been established, while there were no DAMUs in 2014.
- 54% of livestock owners reported using weather advisories twice a week in 2020 as compared to 8% of livestock owners in 2014.
- The number of Farmers awareness programs organized increased from 13 (2014) to 1133 In 2022.
- Launch of a dedicated Meghdoot Mobile App for weather forecast and agro advisory services in 2019 and extended to 13 languages
- 59% of farmers reported using weather advisories twice a week in 2020 as compared to 7% of farmers in 2014.

District/ Block Level Agromet Advisory Service System under GKMS



Dissemination of weather forecast and AAS through

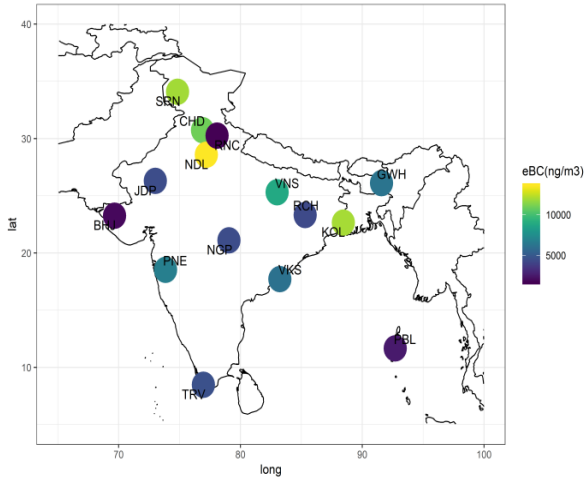
- Meghdoot Mobile App in English and 12 Indian languages (Hindi, Telugu, Assamese, Gujarati, Kannada, Malayalam, Marathi, Odia, Tamil, Mizo, Bengali and Punjabi).
- Whatsapp group: 1.6 million farmers from 3,995 blocks
- Common Service Centre (CSCs)
- Services integrated with Agriculture Produce and Livestock Market (APMC): 982 Mandis
- Farmers accessing the information from State Govt. Website/Mobile Apps: >10.48 million
- Farmers receiving SMS through PPP mode: 10.25 million
- Dissemination during extreme weather events: SMSs through **mKisan portal**

	YAAS (22-26 May 2021)	Deep Depression (9-14 Sept.2021)	GULAB (25-28 Sept.2021)	Depression over Bay (10-12 Nov.2021)	JAWAD (30 Nov.-6 Dec.2021)	Deep Depression (04 Mar.2022)	SITARANG (22-25 Oct.2022)	MOCHA (10-15 May 2023)	BIPARJOY (13-15 Jun. 2023)
No. of SMS Sent (Lakh)	29.8	8.11	84.53	4.79	46.1	7.56	31.74	17.15	208.36

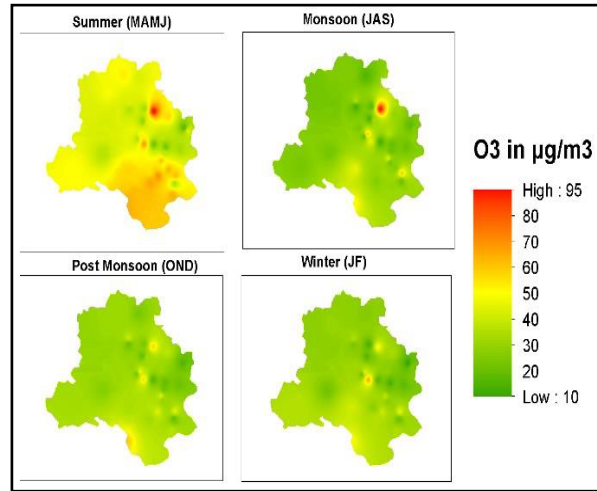
4.15 Air Quality Monitoring and Forecast Services

- The System of Air Quality Forecasting And Research to provide location-specific information on air quality in near real-time and its forecast 1-3 days in advance was launched in Delhi and Pune in 2014. Later, it was extended to Mumbai and Ahmedabad. The air quality forecast services have been extended to 40 cities since 2023.

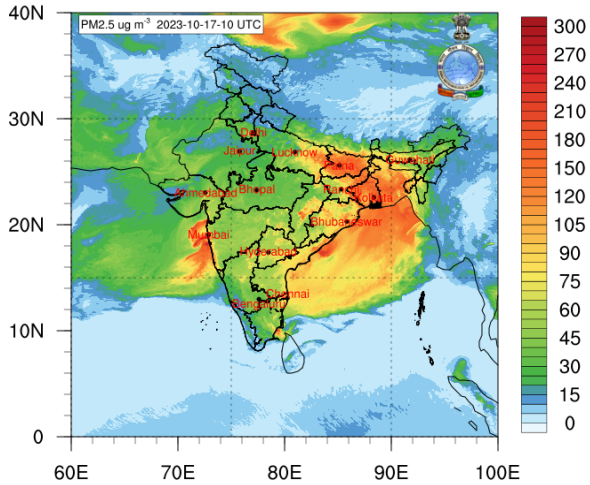
- To strengthen the forecasting services, the Air Quality Early Warning System (AQ-EWS) was developed under the aegis of the Ministry of Earth Sciences in 2018, jointly by the scientists of the Indian Institute of Tropical Meteorology (IITM), Pune, India Meteorological Department (IMD), National Centre for Medium-Range Weather Forecasting (NCMRWF).
- The Air Quality Early Warning System (AQ-EWS) has been introduced since 2018.
- New numerical models, System for Integrated Modeling of Atmospheric Composition (SILAM) and Environmental information Fusion SERVICE (ENFUSER) for Air Quality Early Warning Systems have been operationalized by IMD since 2018.



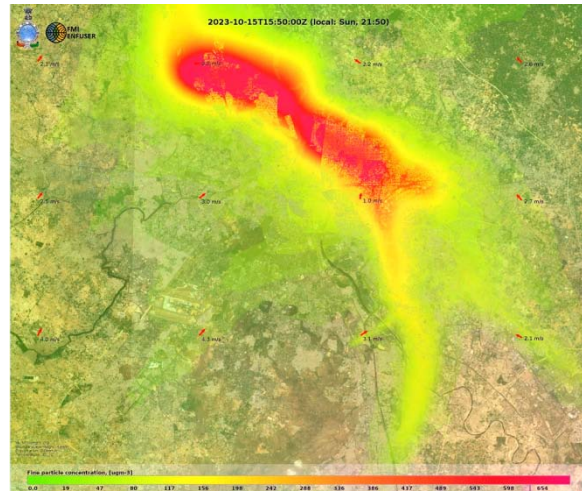
Variability of annual mean equivalent Black Carbon (eBC) aerosol concentration over India at IMD eBC aerosol observation network



Spatial distribution of Surface Ozone over Delhi during different seasons



PM2.5 Forecast using SILAM model



PM2.5 Forecast using ENFUSER over Delhi

4.16 Polar Meteorological Service

The meteorological observations, atmospheric ozone, and solar radiation are continuously monitored at Maitri and Bharati. It is well understood that the Polar Regions play a vital role in regulating the weather & climate of different continents and the world as a whole. Efforts have been made to find and establish a correlation between its weather &

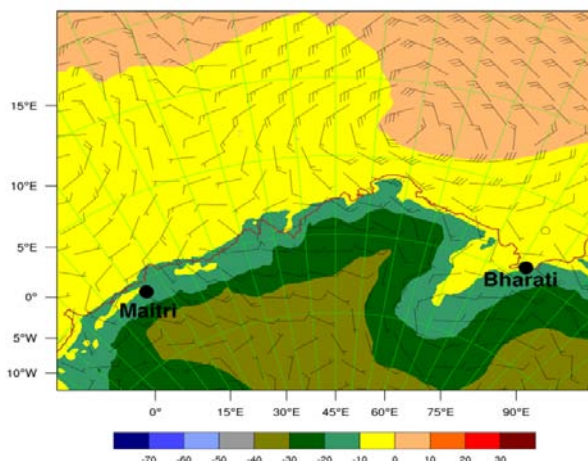
its influence on India. Substantial meteorological activities are required to support logistic operations in the Antarctic and the Southern Ocean. The meteorological data bank, formed over the years of observation, is fundamental to our understanding of its climatology and its contemporary process of global relevance, ozone depletion, atmosphere pollution, climate change, melting of ice shelves, Blizzards, glaciers and sea level rise, etc.

- India landed in Antarctica on 9th January, 1982 and established a base camp on the ice shelf.
- In 1983-84 during the third expedition, a permanent station Dakshin Gangotri was established and commissioned on the ice shelf, off the princess Astrid Coast in Central Dronning, Maud Land.
- India built a second permanent station Maitri on Schirmacher Oasis situated in East Antarctica, during 1988-89, as the first research Station got buried under ice.
- A third state of art Bharati Station was raised during 2011-12. It is about 3000 km from Maitri Station. But the Meteorological observatories at Bharati Antarctica were started in 2014.
- The observed and forecast weather bulletin as depicted in the figures are issued regularly to support the logistic operation at the Maitri and Bharati stations.

The Polar WRF model was operationally run by IMD at 9 km resolution over Maitri station in 2014. In 2022 the Polar WRF model was upgraded to version 4.1.1 with 3 km horizontal resolution at both places (Maitri and Bharati) and is operationalized by IMD for weather forecasting over East Antarctica mainly focusing on Maitri and Bharati.

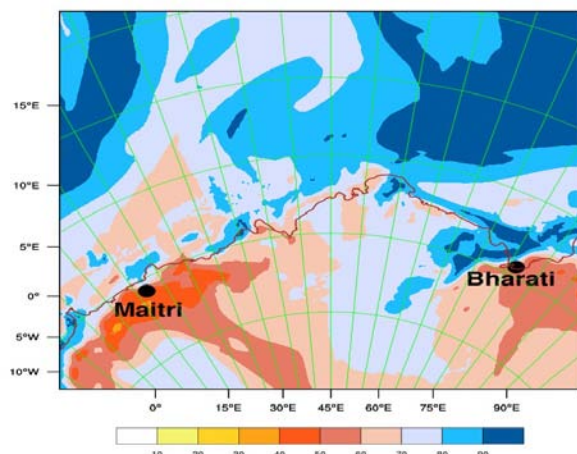
Forecast of 10m wind and 2m temperature

IMD MESOSCALE(03 Km) Analysis for Polar Region
10m Wind(Kts) & 2m Temp.(°C) at 00 UTC of 08-01-2024



Forecast of 2m Relative Humidity

IMD MESOSCALE(03 Km) Analysis for Polar Region
2m Relative Humidity(%) at 00 UTC of 08-01-2024

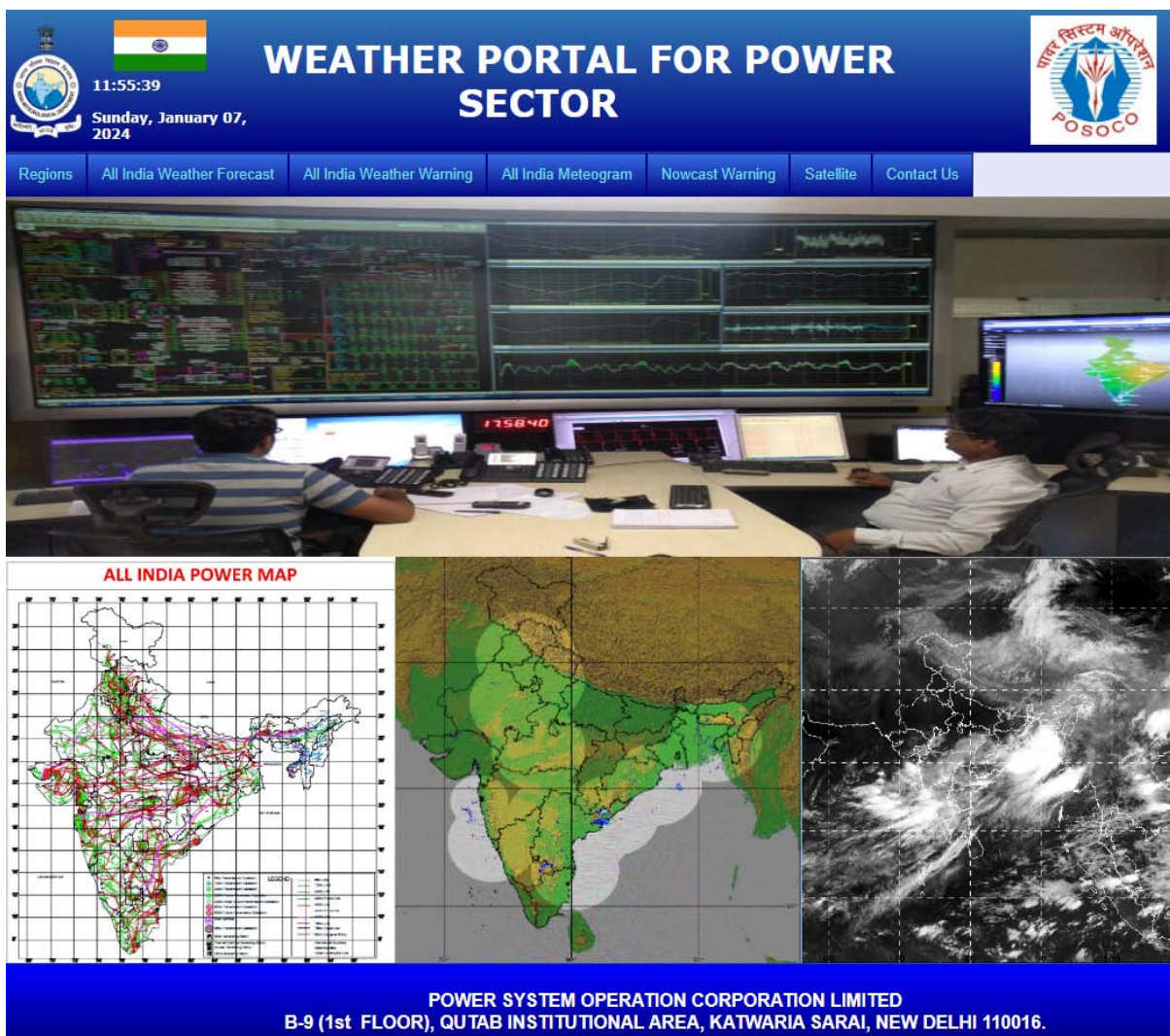


4.17 Forecast Services for Power Sector

- IMD is providing weather forecast & advisories to various organizations such as Grid-India and NHPC. IMD and Power System Operation Corporation Ltd. (POSOCO)/Grid-India had signed MoU on 18th May 2015 to take various initiatives under the aegis of this partnership like workshops at the national and regional level, development of weather portal providing information on weather for better grid management. Subsequently, a follow-up MoU was signed by IMD & POSOCO/Grid-

India on 3rd June 2022 to further enhance the scope of weather services to the power sector.

- Weather Portal for Power System has been developed using readily available products of IMD (Such as Weather forecasts, Weather warning, Radar Images, meteograms and Satellite Image). Weather information provided on the Portal is being used by the Power System Operators across India for secure, reliable and economical operation of the Indian grid.



WEATHER PORTAL FOR POWER SECTOR

11:55:39
Sunday, January 07, 2024

Regions All India Weather Forecast All India Weather Warning All India Meteogram Nowcast Warning Satellite Contact Us

ALL INDIA POWER MAP

POWER SYSTEM OPERATION CORPORATION LIMITED
B-9 (1st FLOOR), QUTAB INSTITUTIONAL AREA, KATWARIA SARAI, NEW DELHI 110016.

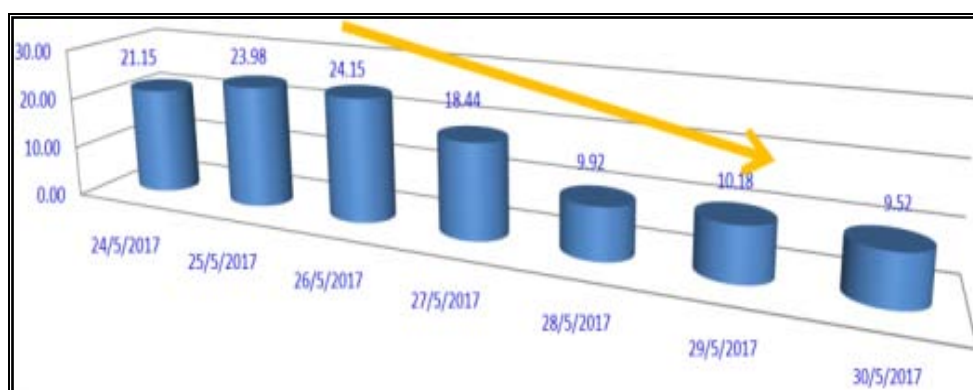
Advisories issued by IMD have helped the power sector in the following ways:

- IMD products are regularly being used to take proactive steps for power demand estimation and for maintaining the system reliability and security of the Indian grid.
- The weather portal also allows the real-time grid operator to remain more vigilant in case of heavy wind, cyclone, or heavy lightning which may lead to increased equipment tripping.
- Weather & rainfall forecasts for NHPC's hydro-projects at Chenab, Arunachal Pradesh, and Assam have helped in effective planning, timely warning and evacuation of man-machinery.
- Accurate anticipation of extreme weather conditions such as snowstorms, dust storms, high winds, thunderstorms and cyclones helps in advance operational planning, secure system operation and early restoration.

- v. Solar and wind forecasting services are being provided to GRID-INDIA for effective grid management.
- vi. The warnings of inclement weather help in anticipating a sudden unprecedented decrease in demand.
- vii. Warning and cyclone tracking by IMD has proved to be very useful for disaster preparedness and mobilizing resources for quick recovery.

Economic Benefits

- **Grid Management:** Forecast of thunderstorm weather warning, live radar imagery enables revision of schedule for backing down of generating stations which avoids huge under drawl of power thereby also ensuring grid security.
 - **Hydropower generation:** 5 Days of rainfall/weather forecast and alerts have helped in timely man and machinery evacuation. 4-week extended range rainfall forecast has helped in the planning and construction of Hydropower projects
 - **Protection from Fog:** Fog forecasting helps to mitigate the adverse effect of tripping of EHV lines due to fog coupled with pollution.
 - **Power Infrastructure Safety:** Extreme Weather Forecasting such as tropical depressions and cyclones helps in taking proactive safety measures and regulation of power generation.
 - **Renewable Forecasting:** WRF-based Wind Forecast data is being provided for various wind power generation locations.
- » **In the POWER sector accurate anticipation of extreme weather conditions i.e. snowstorms, dust storms, High winds, and thunderstorms, heavy rain, cyclones etc. facilitate advance operation planning, secure system operation and early restoration of the affected areas. There has been significant utilisation of weather and climate information by the power sector in India.**
- » **Based on independent Survey by National Centre for Applied Economic Research(NCAER) in Andhra Pradesh and West Bengal in 2015, The improvements in forecast accuracy also resulted in significant gains to various sectors such as power sector saved around 500 crores each from cyclone warnings during Phailin (2013) and Hudhud (2014).**



- Meteogram, wind and rain forecast for 27/28/29-05-2017 helped in better load assessment of UP control area by U.P. State Load Despatch Centre.
- As anticipated, UP demand went down from 19000 MW to 17000 MW due to change in weather conditions.

- Accordingly, STOA & purchase from Power Exchange of the order of 2000 MW was reduced. i.e. Backing down of approximately 13 MU of costly thermal generation.

4.18 Climate Services

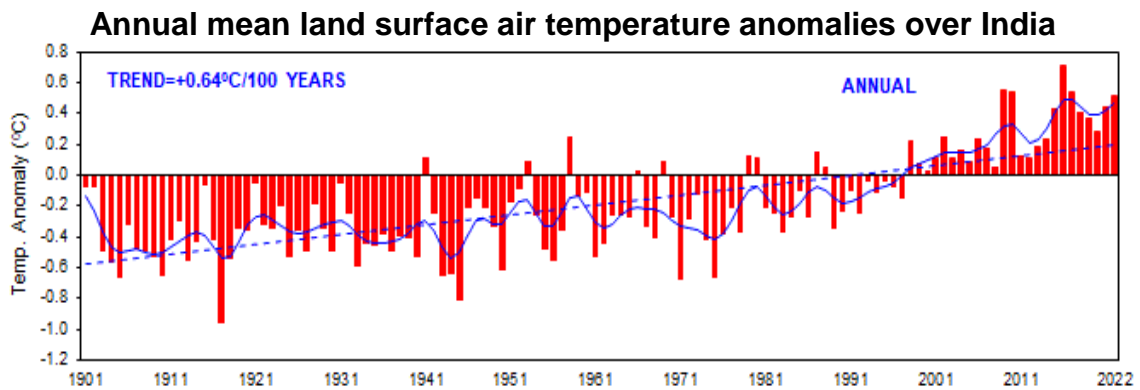
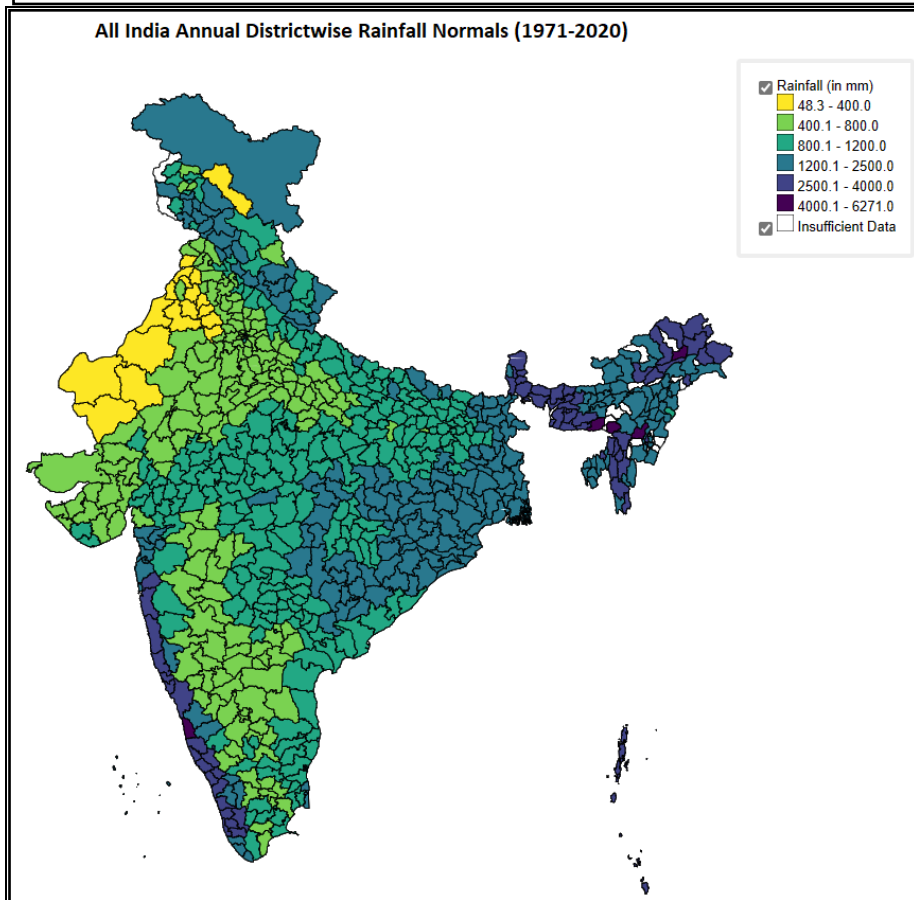
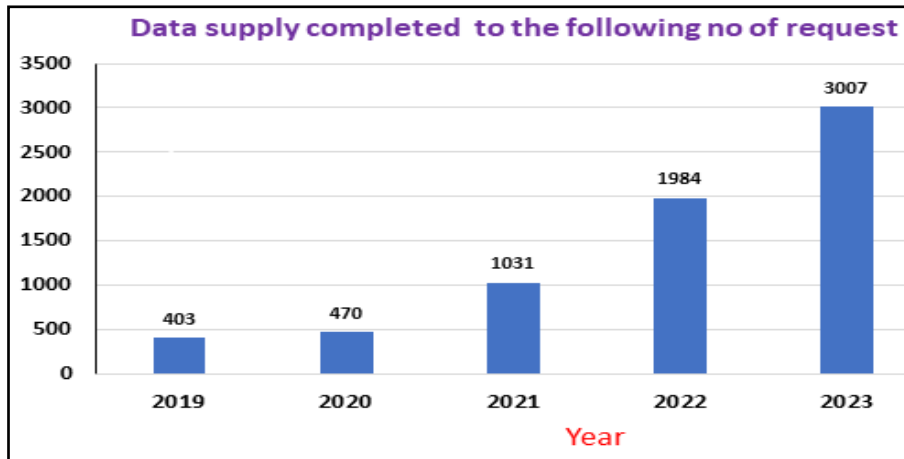
- It is a well-accepted fact that the possible consequences of global warming and Climate Change are spreading to all spheres of life with many vital sectors will be under stress. In this scenario, the demand for climate services by society has increased manifold.
- IMD is fortunate to have a long history and advanced capabilities of climate monitoring, research and prediction empowering its climate services, and internationally acclaimed institutions dealing with different aspects of climate and its impacts. These data sets are archived and made available through the **National Data Centre, IMD Pune.**
- **Climate information, climate monitoring, climate prediction and Climate applications are the 4 major components of Climate services.**
- **Climate publications for normal and extremes at station and district levels for the recent 30 years (1991-2020) have been brought out for use by many users.**
- India Meteorological Department (IMD) provides services to weather-sensitive sectors viz. agriculture, irrigation, shipping, aviation, health, tourism, marine, offshore oil explorations, etc. as well as the general public.

Climate Data

- ❖ Meteorological data from the entire country are received at the National Data Centre (NDC), IMD, Pune.
- ❖ After standard quality check process, these data are archived permanently at NDC.
- ❖ Climatological Normals and other climate products are prepared.
- ❖ The data are also made available to different users including general public
- ❖ Climate publications for normal and extremes at station and district levels

Data Supply Portal (DSP) : <https://dsp.imdpune.gov.in>

- ❖ IMD's Data Supply Services has been made online from 2019.
- ❖ This portal was developed in-house for online management of all activities related to the supply of meteorological data
- ❖ To enhance efficiency & transparency and
- ❖ To reduce the data delivery time.
- ❖ Four-fold increase in number of data requests after the services have been made online.
- ❖ The data delivery time has reduced from days to a few minutes.



Climate Applications Products (Five Important Sectors)



- ❖ **Seasonal and Extended range forecast provides useful skill for applications in Agriculture, Hydrology, Energy, Health and Disaster Management.**

National Framework of Climate Services (NFCS)

- The concept of a **National Framework for Climate Services (NFCS)** that can be implemented in India, and propose collaborative efforts between various stakeholders for delivering full-value chain climate services in India. The NFCS is premised on the GFCS to strengthen the production, availability, delivery and application of science-based climate monitoring and prediction services.
 - **IMD in working towards the implementation of National Frameworks for Climate Services (NFCS) – India.**
- Although various climate services exist in the country, the integration of climate services into government policies and decision-making processes is still limited
- Establishing an NFCS is therefore expected to be helpful to the country in terms of co-production and delivery of climate services as a sustainable multi-agency collaborative enterprise. The NFCS can play a key role by developing processes and guidelines that will assist governments, the public, and industries in integrating climate services into decision-making to manage the risks and opportunities associated with extreme climate events.

4.19 Specialized forecasts

In addition to the regular forecasts issued by IMD throughout the year, some specialized forecasts are also issued for different sectors such as Tourism, Highway, Mountain weather, Mata Vaishno Devi Yatra and Amar Shri Amarnath Ji Yatra as per the requirement.

Tourism Forecast



Forecast for Prayagraj

Sunday January 07, 2024

Tourism Forecast for Prayagraj

Maximum (2024-01-06) Departure: -3 °C	18.4 °C	Sunrise (IST): -- Sunset (IST): --
	Minimum (2024-01-07) Departure: 5 °C	
R.H. at 0830 hrs: (2024-01-07)	94 %	Moonrise (IST): -- Moonset (IST): -- R.H. at 1730 hrs: (2024-01-06) 94 %

Past24 Hrs Rainfall ending at 0830 IST (in mm): NIL

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Max Min	Max Min	Max Min	Max Min	Max Min	Max Min	Max Min
20.0 12.0	21.0 11.0	20.0 12.0	21.0 13.0	21.0 12.0	22.0 11.0	22.0 11.0
FOG	FOG					

(Climatological & Extreme Weather Information)

WEATHER INFORMATION FOR SHRI MATA VAISHNO DEVI YATRA

SHRI MATA VAISHNO DEVI YATRA ROAD MAP

YATRA ROUTE WEATHER ADVISORY

VALUE ADDED NOWCAST FOR MATA VAISHNO DEVI YATRA

CURRENT OBSERVATIONS

NWP PRODUCTS FOR SHRI MATA VAISHNO DEVI

LOW LEVEL WIND AND TEMPERATURE CHARTS FOR HELICOPTER OPERATION

THREE DAYS FORECAST

JAMMU DIVISION

SATELLITE IMAGES

INSAT - 3D

VISIBLE

INFRA-RED 1

SHORT WAVE INFRA-RED

INFRA-RED 1 - BRIGHTNESS TEMPERATURE

ANIMATION OF HALF HOURLY IMAGES

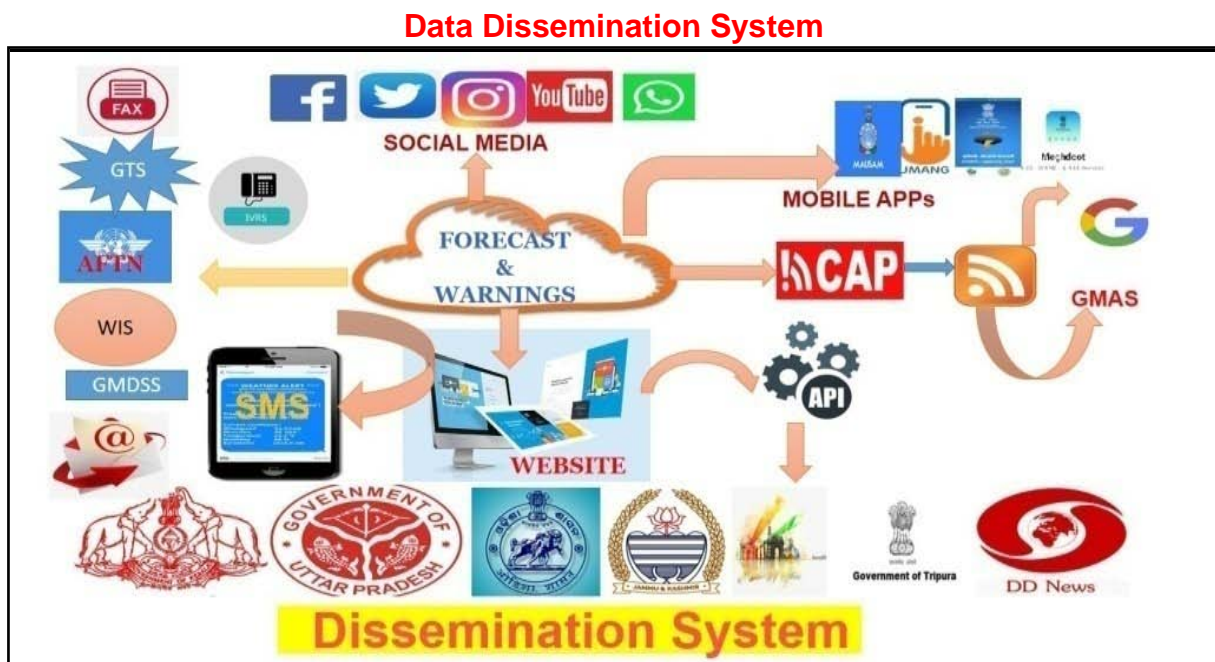
HOME

4.20 Dissemination of forecasts and warnings

- In 2014, Warning Dissemination was through Conventional methods, Websites and SMS only. By 2023, it is done through various weather Apps such as Meghdoot,

Mausam, Damini and SAFAR Air, all the social media platforms, etc. The Common Alert Protocol (CAP) was implemented by 2023 with the active involvement of IMD and extensively used by different State Disaster Management Authorities (SDMAs) for cyclone alerts and other severe weather warnings. It was not available during 2014.

- Web-GIS-based service products have been introduced for providing real-time monitoring and forecasting information to the public, disaster managers and stakeholders on severe weather hazards like cyclones, heat waves, cold waves and heavy rainfall which were not available till 2014.
- More than 30 public and private organizations are using IMD's 16 Application Programming Interfaces (APIs). These include NITI Aayog, National Disaster Management Authority, Incredible India, eNAM, National Rice Research Institute Cuttack, SDMAs/Agriculture Dept:(AP, Odisha, Karnataka, MP, Chandigarh, Kerala, A&N Islands, Uttarakhand, J&K, UP), KRC Net Portal (MoES), Disaster Management Support Group ISRO, ICAR-NIASM, National Programme on Climate Change and Human Health, RIMES, NHA, NHPC, C-DOT, Media, Apple.com and some other private sectors.



Dissemination of forecast and warning, the following modes are used:

- Mass Media:** Radio/TV, News Paper network (AM, FM, Community Radio, Private TV): Prasar Bharati and private broadcasters
- Weekly & Daily Weather Video
- Internet (e-mail), ftp
- Public Website (mausam.imd.gov.in)
- IMD Apps: Mausam/ Meghdoot/DAMIN/RAIN ALARM
- Social Media: Facebook, Twitter, Instagram, BLOG

Twitter: <https://twitter.com/Indiametdept>

Facebook: <https://www.facebook.com/India.Meteorological.Department/>

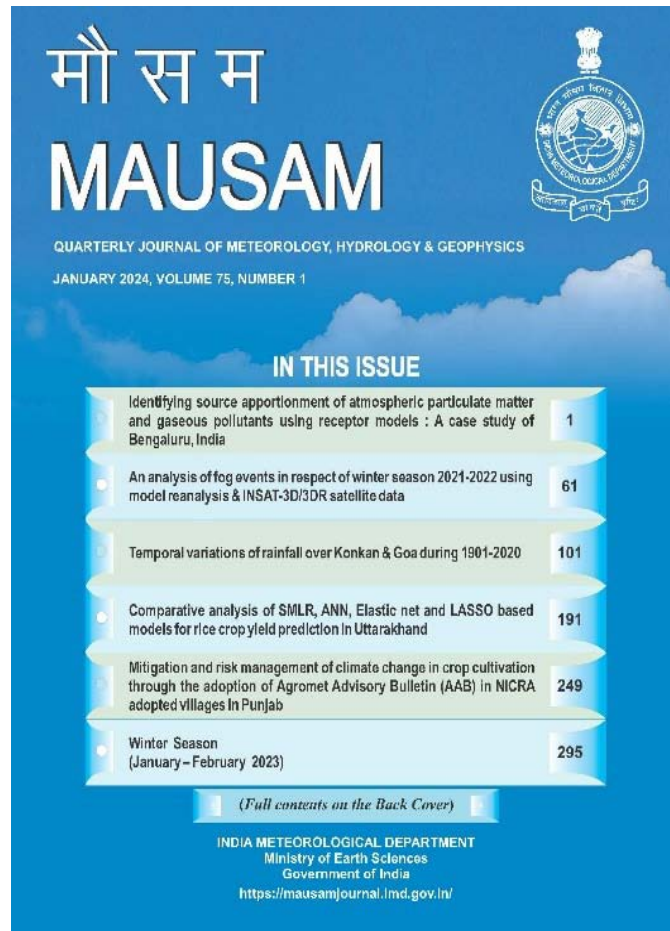
Blog: <https://imdweather1875.wordpress.com/>

Instagram: https://www.instagram.com/mausam_nwfc

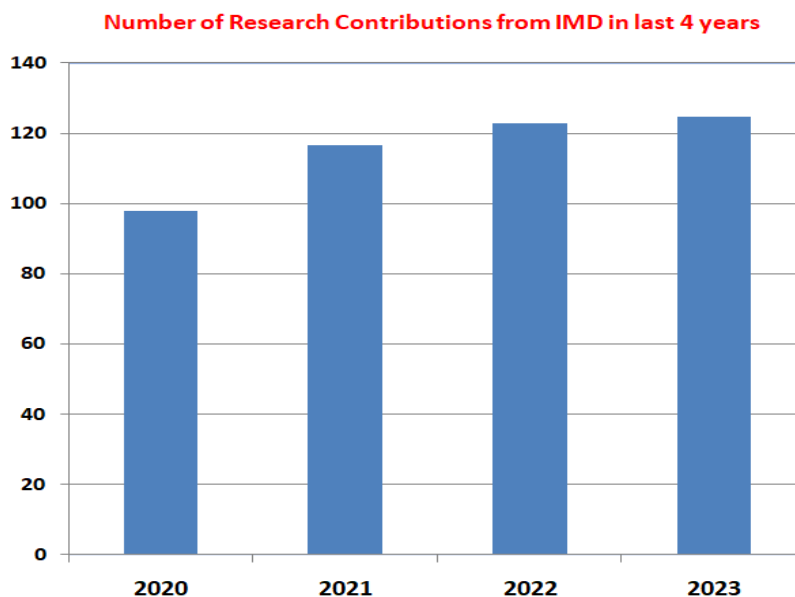
Youtube: https://www.youtube.com/channel/UC_qxTReoq07UVARm87CuyQw

4.21 Research & Development and Publications

- Exploring advancements and conducting research play a crucial role in enhancing operational weather forecasting, thereby contributing to the overall improvement in the quality of weather and climate services provided to diverse users.
- Considering this, IMD brought out a quarterly journal in 1950 (presently named “MAUSAM”).
- India Meteorological Department’s Quarterly International Research Journal ‘MAUSAM’ has been made online (<https://mausamjournal.imd.gov.in/index.php/MAUSAM>) since 2021. Since then, the journal has been making its way to advancement in the world of Scientific Journals.
- All the research articles (since the origin of ‘MAUSAM’, 1950) have been uploaded on the website and the Digital Object Identifiers (DOI’s) for all of them have been activated and are working successfully.
- The impact factor the journal rated by several agencies has been increased and at the maximum for the past three years. Impact factor (IF) of Journal “MAUSAM”: **Scopus is 1.40 for 2023.**
- During the last 74 years, IMD has brought out **28 Special Issues of MAUSAM** covering various disciplines of Earth and Atmospheric Sciences with the last special issue released on 23rd March 2023 as the proceedings of the 7th International Workshop on Monsoon (IWM-7).
- Number of research papers received on MAUSAM journal portal are increasing exponentially. For the year 2023 : January to March Qtr – 70; April to June Qtr – 61; July to September Qtr – 77; October to December Qtr – 73.



- In the last 5 years IMD has signed many MoU with various research institutes, universities etc for the encouragement of collaborative research and for the expansion of meteorological services and research activities.
- Over the recent years, IMD Scientists have contributed significantly to the field, publishing a substantial quantity of research papers in both international and national journals including “MAUSAM”.



4.22 Highlights of IMD visions for 2030

There is a considerable scope for further accelerating the initiatives taken by IMD to enable the country to become a world leader in providing high quality weather and climate services, and contribute to economic and societal benefits. IMD aims to address gaps in forecast and warning services, focusing on enhancements in observational networks, improving numerical models, use of new tools and technologies, and expanding outreach to include new sectors for weather and climate services. The highlights of IMD's vision for 2030 are given below.






- The weather forecasting accuracy will further increase by 10-15% for all types of severe weather by 2030.
- IMD has introduced several new sectoral applications to cater to the present and future user requirements. A corresponding improvement in the weather forecast and service delivery will be carried out by further up-gradation of existing communication and forecasting systems. The new systems will be scalable and capable of adding new observations and modelling products.
- Outreach of Agromet Advisory Services will be further expanded from Block level to Panchayat level in next five year through state government platforms, Kisan Portal, Public–Private Partnership (PPP) and other service providers across the country.
- Impact based forecast initiated in recent years will be enhanced dynamically with hazard & impact modelling and risk assessment for all hazards.
- To set up atmospheric observational network at 25x25 km grid and upper air observations at 100x100 km, complimented by Multi-platform Satellite and air-craft based profiler observations, Doppler Radars, Wind profilers, Radiometers, Lightning detectors, and LIDARs.
- Develop an Advanced Weather Prediction System, for village level forecasts, skilful for next 3-7 days and develop advisories for sectors for like Agriculture, Disaster Management, Water resources, Power, Tourism and Pilgrimage, Smart Cities, Renewable Energy Sector and Transport, Urban, Health, Environment sectors.
- To minimize the damage due to thunderstorms and lightening, a more accurate and high spatial resolution & location-specific forecast as well as Nowcast of thunderstorms need to be enhanced by increasing lead period and accuracy. Therefore, it is aimed to develop a thunderstorm research test bed over the eastern part of India will be developed to study the dynamical, microphysical and electrical characteristics of thunderstorms.
- Application products based on extended range forecast for various sectors will continue to be developed including tailor made forecast and warning products for private industries like power sector, ONGC, aviation, energy sector & state governments.
- Develop Panchayat level weather and climate service centres for better coordination with the users and government officials for various applications including disaster management.
- Develop an Advanced National Climate Services Framework to cater to the needs of Agriculture, Water Resources, Alternate Energy Resources and Health on the basis of location specific and user specific knowledge of the climate variability and predictions of climate variables.
- Develop a State-of-the-Art Support System for Aviation Safety with the advanced meteorological instruments and advanced forecasting tools for all the civil airports in the Country.

- Improve probabilistic prediction system based on a coupled model of land-ocean-atmosphere for reliable extended range (up to 15-20 days) and seasonal (for all the four seasons) forecasts of rainfall and temperatures for smaller spatial scales at district to block levels.
- Monitor the three dimensional variability of regional hydrological cycle and assess its expected changes and impacts in the future.
- Carry out process studies of the atmosphere (aerosols, clouds, land surface processes, boundary layer, and atmospheric chemistry) through setting up of research test beds which are required for substantial improvements in dynamical models.
- Carry out cutting-edge research studies on climate variability including monsoons, meteorological droughts, desertification, land use changes using observations and modelling.
- Develop Urban Meteorology Services with dense Meso network and modelling strategy to cater to the needs of growing cities in the country.
- Implement an Integrated Himalayan Meteorology Programme for meeting the growing challenge and needs of the Himalayan States.
- Application of AI/ML in NWP for pre-processing and post-processing of data.
- Though the numerical models are improving to give better forecast skills, there is a need to utilize the Artificial Intelligence/Machine learning (AI/ML) framework for observations and NWP models for customized value-added improved forecasts for different sectors.






Meteorological Regions


India Meteorological Department (IMD)
Ministry of Earth Sciences (MoES)
Government of India
 Lodi Road, New Delhi -110003

Legend

-  Meteorological Centre (MC)
-  Regional Meteorological Centre (RMC)
-  Climate Research and Services (CRS)
-  India_State
-  India_SubDivision

Region

-  North Region
-  Central Region
-  East Region
-  North East Region
-  West Region
-  South Region

35°0'0"N 30°0'0"N 25°0'0"N 20°0'0"N 15°0'0"N 10°0'0"N 60°0'0"E 65°0'0"E 70°0'0"E 75°0'0"E 80°0'0"E 85°0'0"E 90°0'0"E 95°0'0"E 100°0'0"E

